TP 13999E

Three Aircraft Ground Icing Research Activities During the 2001-02 Winter

Prepared for
Transportation Development Centre

On behalf of

Civil Aviation
Transport Canada

And

The Federal Aviation Administration
William J. Hughes Technical Center

APS
Aviation Inc.

November 2002
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Three Aircraft Ground Icing Research Activities During the 2001-02 Winter

by

Alia Alwaid
and
Peter Dawson

APS
Aviation Inc.

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Final Version 1.0

The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

The Transportation Development Centre does not endorse products or manufacturers. Trade or manufacturers' names appear in this report only because they are essential to its objectives.

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PREFACE

At the request of the Transportation Development Centre of Transport Canada, APS Aviation Inc. (APS) has undertaken a research program to advance aircraft ground de/anti-icing technology. The specific objectives of the APS test program are the following:

- To develop holdover time data for all newly qualified de/anti-icing fluids;
- To evaluate the parameters specified in Proposed Aerospace Standard 5485 for frost endurance time tests in a laboratory;
- To evaluate weather data from previous winters to establish a range of conditions suitable for the evaluation of holdover time limits;
- To develop holdover times in snow using a more realistic protocol for Type I fluid endurance time testing;
- To further evaluate the flow of contaminated fluid from the wing of an aircraft during simulated takeoff runs;
- To examine the change in viscosity with the application process of Type IV fluids;
- To further evaluate hot water deicing;
- To compare endurance times in natural snow with those in artificial snow;
- To provide support for tactile tests at the Toronto Airport Central Deicing Facility;
- To utilize ice sensors for a pre-takeoff contamination check;
- To prepare the JetStar and Canadair RJ wings for thermodynamic tests; and
- To provide support services to Transport Canada.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2001-02 are documented in nine reports. The titles of the reports are as follows:

- TP 13991E Aircraft Ground De/Anti-icing Fluid Holdover Time and Endurance Time Test Program for the 2001-02 Winter;
- TP 13992E Evaluation of Laboratory Test Parameters for Frost Endurance Time Tests;
- TP 13993E Impact of Winter Weather on Holdover Time Table Format;
- TP 13994E Generation of Holdover Times Using the New Type I Fluid Test Protocol;
- TP 13995E Aircraft Takeoff Test Program for Winter 2001-02: Testing to Evaluate the Aerodynamic Penalties of Clean or Partially Expended De/Anti-Icing Fluid;
- TP 13996E Influence of Application Procedure on Anti-icing Fluid Viscosity;

- TP 13997E Endurance Time Tests in Snow: Reconciliation of Indoor and Outdoor Data 2000-02;
- TP 13998E Exploratory Aircraft Ground Deicing Research for the 2001-02 Winter; and
- TP 13999E Three Aircraft Ground Icing Research Activities During the 2001-02 Winter.

This report, TP 13999E, has the following objective:

- To provide support to TDC and others on research activities carried out during the winter of 2001-02.

This report contains three studies:

- Replacement of tactile check with ground ice detection systems: Preliminary data collection and analysis.
- Development of test specifications for forced air deicing systems; and
- Cooperation in the development of ground minimum operational performance specification for ground ice detection systems.

This report also contains an account of the test procedures and presentations that were produced for the program activities conducted in 2001-02.

ACKNOWLEDGEMENTS

This research has been funded by Transport Canada, with support from the U.S. Federal Aviation Administration, William J. Hughes Technical Center. This program could not have been accomplished without the participation of many organizations. APS would therefore like to thank the Civil Aviation Directorate and the Transportation Development Centre of Transport Canada, the U.S. Federal Aviation Administration, National Research Council Canada, the Meteorological Service of Canada (formerly known as Atmospheric Environment Services Canada), and several fluid manufacturers. Special thanks are extended to US Airways Inc., Air Canada, American Eagle Airlines Inc., the National Center for Atmospheric Research, AéroMag 2000, Aéroports de Montreal, Ottawa International Airport Authority, ATCO Airports, Aviation Boréale, GlobeGround North America, and Dow Chemical Company for provision of personnel and facilities, and for their co-operation with the test program. APS would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Nicolas Blais, Yagusha Bodnar, Alison Cairns, Robert Paris, Parimal Patel, Harvinder Rajwans, Ruth Tikkanen, Bob MacCallum, Trevor Leslie, Chris McCormack, and David Belisle.

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Research reports produced on behalf of Transport Canada for testing during previous winters are available from the Transportation Development Centre (TDC). Nine reports (including this one) were produced as part of this winter's research program. Their subject matter is outlined in the preface.

16. Abstract

This report contains the results of three studies conducted by APS Aviation Inc. on activities related to aircraft deicing research.

Replacement of Tactile Check with Ground Ice Detection Systems: Preliminary Data Collection and Analysis

A tactile inspection of certain aircraft is necessary following deicing to ensure that the wing is free of ice. GlobeGround, the operator of the Central Deicing Facility at Toronto International Airport, wishes to examine whether ice detection systems could replace the tactile inspection. A test procedure was developed to assist GlobeGround in collecting data using an ice detection system in this application. The APS team logged and analyzed the data. Results of the analysis were submitted to GlobeGround in early April 2002.

Development of Test Specifications for Forced Air Deicing Systems

The SAE G-12 Aircraft Ground Deicing Equipment Subcommittee identified the need for an official process for operators to test the use of forced air to assist in certain deicing applications and, based on successful outcomes, request approval from authorities to use the forced air systems in their deicing operations. Test procedures and approval processes were developed for specific forced air deicing applications.

Cooperation in the Development of Ground Minimum Operational Performance Specification for Ground Ice Detection Systems

APS held a demonstration of the procedures required to conduct laboratory trials for evaluating the minimum operational performance requirements of ice detection sensors. In addition, APS prepared a test procedure in 2001-02 for a study funded separately by a sensor manufacturer wanting to certify its remote ground ice detection system. A number of challenges were noted in the methodology and in the procedures to be followed while conducting the tests specified in Aerospace Standard AS 5116A. As a result, APS presented these issues and proposed changes to AS 5116A at the SAE G-12 Ice Detection Subcommittee meeting in Frankfurt, Germany, on June 6, 2002.

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Les rapports de recherche produits au nom de Transports Canada sur les essais réalisés au cours des hivers antérieurs peuvent être obtenus auprès du Centre de développement des transports (CDT). Le programme de la saison hivernale a donné lieu à neuf rapports (dont celui-ci). On trouvera dans la préface l'objet de ces rapports.

16. Résumé

Ce rapport présente les résultats de trois études réalisées par APS Aviation Inc. (APS) concernant des activités entourant le dégivrage des aéronefs au sol.

Remplacement de la vérification tactile par des systèmes de détection de givrage : collecte et analyse de données préliminaires

Il est parfois nécessaire de procéder à une inspection tactile des aéronefs après dégivrage, pour s'assurer que l'aile est vraiment exempte de givrage. GlobeGround, l'exploitant de l'installation centrale de dégivrage à l'aéroport international de Toronto, souhaitait examiner la possibilité de remplacer l'inspection tactile par des systèmes de détection de givrage. Les chercheurs ont élaboré une procédure d'essai, dont GlobeGround s'est servi pour mettre en oeuvre un système de détection de givrage et en colliger les données. L'équipe d'APS a ensuite enregistré et analysé ces données. Les résultats de cette analyse ont été remis à GlobeGround au début d'avril 2002.

Élaboration des spécifications d'essai de systèmes de dégivrage à air forcé

Le sous-comité G-12 de la SAE sur les systèmes de dégivrage au sol a reconnu la nécessité d'établir un processus formel pour donner aux exploitants de services de dégivrage la possibilité d'utiliser, à l'essai, un système à air forcé dans certaines applications de dégivrage, et demander ensuite, forts de résultats concluants, l'autorisation des organismes de réglementation d'intégrer ces systèmes à leurs programmes de dégivrage. Une méthode d'essai et un processus d'approbation ont été élaborés pour des applications précises de dégivrage à air forcé.

Coopération à l'élaboration de spécifications de performances opérationnelles minimales pour les systèmes de détection de givrage

APS a organisé une démonstration des procédures devant encadrer les essais en laboratoire destinés à définir les performances opérationnelles minimales des détecteurs de givrage. Toujours en 2001-2002, APS a élaboré une procédure d'essai pour une étude financée séparément par un fabricant de détecteurs, qui voulait faire homologuer son système de détection de givrage à distance. Divers problèmes ont été notés dans la méthodologie et les procédures d'essai prescrites par la norme Aerospace Standard (AS 5116A). APS a donc fait état de ces problèmes et proposé des modifications à la norme AS 5116A à la réunion du sous-comité G-12 de la SAE sur la détection de givrage, qui a eu lieu à Francfort, en Allemagne, le 6 juin 2002.

17. Mots clés
Endurance, durée d'efficacité, liquides de dégivrage, caméra, vérification tactile, détection de givrage au sol, système à air forcé, infrarouge, spécification de performances opérationnelles minimales

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EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre of Transport Canada (TC), APS Aviation Inc. (APS) has undertaken research activities, co-sponsored by the U.S. Federal Aviation Administration (FAA), to further advance aircraft ground de/anti-icing technology.

Several research reports for testing of de/anti-icing technologies have been produced for this winter test program 2001-02. The subject matter of these reports is described in the preface of this document. This report contains the documentation of the work conducted by APS on activities related to aircraft deicing research. Three studies are included in this report:

a) Replacement of tactile check with ground ice detection systems (GIDS): Preliminary data collection and analysis;

b) Development of test specifications for forced air deicing systems; and

c) Cooperation in the development of ground minimum operational performance specification (GMOPS) for GIDS.

This report also contains the test procedures and presentations that were produced for the program activities conducted in 2001-02.

Replacement of Tactile Check with Ground Ice Detection Systems (GIDS): Preliminary Data Collection and Analysis

GlobeGround, the operator of the Central Deicing Facility at Toronto International Airport, wished to examine whether ice detection systems could replace the tactile inspection. The examination process and the outcome must meet the needs of the approving authority, TC, and be accepted by the airline industry. APS was asked to develop suitable procedures to be used by personnel at GlobeGround for data gathering, and to assist in the analysis of the collected data in order to document the effectiveness of specific ice detection systems proposed for use.

Procedures and data forms were developed by APS for use by GlobeGround during the winter of 2001-02.

It was agreed with GlobeGround that a typical data package for each deicing operation would include:

a) Completed data forms;

b) GlobeGround daily statistics sheets (OPS Reports); and

c) JPEG ice detection images of the wing before and after deicing.

During the winter of 2001-02, GlobeGround collected a limited amount of data, using both the Cox and Company Inc. and Goodrich Corporation ice detection systems.

The completed data forms from the winter of 2001-02 were provided to APS, along with some data forms completed during the previous season. The APS team logged and analyzed the data. Results of the analysis were submitted to GlobeGround in early April 2002.

There was insufficient data collected to support a submission for sensor approval to TC. Additional data will be needed to have a substantial package suitable for submission for approval.

Development of Test Specifications for Forced Air Deicing Systems

The Society of Automotive Engineers (SAE) G-12 Aircraft Ground Deicing Equipment Subcommittee identified the need for an official process for requesting approval from authorities to use forced air deicing systems in operator deicing programs. Such a process would include an approved test procedure and a documented procedure for requesting approval.

Members of the subcommittee requested the cooperation and assistance of the FAA and TC to develop an official test procedure and to define an approval process for selected applications. The two authorities agreed to the request and assigned APS to work with the Forced Air Working Group of the SAE G-12 Equipment Subcommittee.

APS developed two test procedures addressing two specific applications of the forced air systems. One test procedure was for use by operators to examine whether published fluid holdover times can be used for forced air assist applications of Type II or Type IV fluid. Some operators have since conducted tests on specific forced air deicing truck/fluid combinations using the test procedure.

The second test procedure was to assist operators in understanding the acceptability of using forced air with Type I fluid in a first step of a two-step deicing operation. This procedure has also been provided for operator implementation. Test results will also indicate whether it is appropriate to examine the use of forced air with Type I fluid as a one-step process.

Cooperation in the Development of Ground Minimum Operational Performance Specification (GMOPS) for Ground Ice Detection Systems (GIDS)

As part of the activities and the overall test program for TC, APS held a demonstration of the procedures required to conduct laboratory trials for evaluating the minimum operational performance requirements of ice detection sensors.

In addition, APS prepared a test procedure in 2001-02 for a study funded separately by a sensor manufacturer wanting to certify its remote GIDS. A number of challenges were faced in the methodology and procedures to be followed when conducting the tests specified in SAE Aerospace Standard AS 5116A. APS presented these issues and proposed changes to AS 5116A at the SAE G-12 Ice Detection Subcommittee meeting in Frankfurt, Germany, on June 6, 2002.

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SOMMAIRE

À la demande du Centre de développement des transports de Transports Canada (TC), APS Aviation Inc. (APS) a entrepris un programme de recherche, coparrainé par la Federal Aviation Administration (FAA) des États-Unis, visant à faire progresser la technologie du dégivrage et de la protection contre le givre des aéronefs au sol.

Plusieurs rapports traitant d'essais de technologies de dégivrage/antigivre ont été produits pour la saison hivernale 2001-2002. La préface du présent rapport donne un aperçu des sujets abordés dans ces rapports. Le rapport comme tel contient la documentation des travaux réalisés par APS en marge de projets touchant le dégivrage des aéronefs. Trois études sont visées :

a) Remplacement de la vérification tactile par des systèmes de détection de givrage : collecte et analyse de données préliminaires
b) Élaboration des spécifications d'essai de systèmes de dégivrage à air forcé
c) Coopération à l'élaboration de spécifications de performances opérationnelles minimales pour les systèmes de détection de givrage

Le rapport contient également les procédures d'essai et présentations produites dans le cadre du programme de la saison 2001-2002.

Remplacement de la vérification tactile par des systèmes de détection de givrage : collecte et analyse de données préliminaires

GlobeGround, l'exploitant de l'installation centrale de dégivrage de l'aéroport international de Toronto, souhaitait déterminer si l'inspection tactile pouvait être remplacée par des systèmes de détection de givrage. Le plan et les résultats d'une telle étude devaient répondre aux exigences de l'autorité approbatrice, TC, et être acceptés par l'industrie aérienne. C'est ainsi qu'APS a été chargé d'élaborer les procédures qu'allaient utiliser les employés de GlobeGround pour la collecte des données, et d'analyser les données colligées afin de documenter l'efficacité des systèmes de détection de givrage proposés.

APS a élaboré des procédures et des formulaires d'enregistrement des données, dont s'est servi GlobeGround pour sa collecte de données au cours de l'hiver 2001-2002.

Il avait été convenu avec GlobeGround qu'un ensemble de données type devait être constitué pour chaque opération de dégivrage. Un tel ensemble devait comporter ce qui suit :

a) formulaires d'enregistrement des données remplis;
b) feuilles de données statistiques quotidiennes de GlobeGround (rapports d'opérations);
c) photos JPEG de l'aile prises avant et après le dégivrage.

GlobeGround a colligé une quantité limitée de données au cours de l'hiver 2001-2002. Deux systèmes de détection ont été utilisés, soit celui de Cox and Company Inc. et celui de Goodrich Corporation.

Tous les formulaires d'enregistrement des données établis au cours de l'hiver 2001-2002 ont été transmis à APS, de même que d'autres formulaires établis au cours de la saison antérieure. L'équipe d'APS a enregistré et analysé les données. Les résultats de cette analyse ont été remis à GlobeGround au début d'avril 2002.

Les données colligées étaient insuffisantes pour appuyer le dépôt d'une soumission pour l'approbation d'un détecteur auprès de TC. Il faudra obtenir des données additionnelles pour étayer correctement le dossier de demande d'approbation.

Élaboration des spécifications d'essai de systèmes de dégivrage à air forcé

Le sous-comité G-12 de la SAE (Society of Automotive Engineers) sur les systèmes de dégivrage au sol a reconnu la nécessité d'établir un processus formel auquel les exploitants pourraient recourir pour demander aux autorités compétentes l'autorisation d'intégrer l'utilisation de systèmes à air forcé à leurs programmes de dégivrage. Un tel processus doit comporter une méthode d'essai et une procédure documentée de demande d'autorisation.

Les membres du sous-comité ont fait appel à la coopération et à l'aide de la FAA et de TC pour élaborer une méthode d'essai formelle et définir un processus d'approbation aux fins de certaines applications. La FAA et TC ont tous deux accepté de prêter leur concours et ont demandé à APS de collaborer avec le groupe de travail sur les systèmes à air forcé du sous-comité G-12 de la SAE sur les systèmes de dégivrage.

APS a élaboré deux méthodes d'essai, pour deux applications bien précises des systèmes à air forcé. L'une devait permettre aux exploitants de déterminer si les durées d'efficacité publiées pour les liquides de type II et de type IV demeurent valables lorsque ces liquides sont appliqués à l'aide de systèmes à air forcé. Certains exploitants ont depuis utilisé cette méthode pour mettre à l'essai des combinaisons précises de système de dégivrage à air forcé et de liquide.

L'autre méthode d'essai devait aider les exploitants à déterminer dans quelle mesure un système à air forcé peut servir à l'application de liquide de type I en tant que première étape d'une procédure de dégivrage à deux étapes. Cette méthode a aussi été prévue pour être mise en oeuvre par les exploitants. Les résultats de ces essais indiqueront également s'il est opportun d'étudier l'utilisation d'un système à air forcé pour l'application de liquide de type I, à titre d'opération de dégivrage à une seule étape.

Coopération à l'élaboration de spécifications de performances opérationnelles minimales pour les systèmes de détection de givrage

En marge des activités et essais menés pour le compte de TC, APS a organisé une démonstration des procédures devant encadrer les essais en laboratoire destinés à définir les performances opérationnelles minimales des détecteurs de givrage.

Toujours en 2001-2002, APS a élaboré une procédure d'essai pour une étude financée séparément par un fabricant de détecteurs, qui voulait faire homologuer son système de détection de givrage à distance. Divers problèmes ont été notés dans la méthodologie et les procédures d'essai prescrites par la norme Aerospace Standard (AS 5116A). APS a donc fait état de ces problèmes et proposé des modifications à la norme AS 5116A à la réunion du sous-comité G-12 de la SAE sur la détection de givrage, qui a eu lieu à Francfort, en Allemagne, le 6 juin 2002.

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GLOSSARY

APS	APS Aviation Inc.
AS	Aerospace Standard
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration (U.S.)
GIDS	Ground Ice Detection System
GMOPS	Ground Minimum Operational Performance Specification
HOT	Holdover Time
MOPS	Minimum Operational Performance Specification
NRC	National Research Council Canada
OAT	Outside Air Temperature
SAE	Society of Automotive Engineers
TC	Transport Canada
TDC	Transportation Development Centre

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1. INTRODUCTION

Under contract to the Transportation Development Centre of Transport Canada (TC), APS Aviation Inc. (APS) has undertaken research activities, co-sponsored by the U.S. Federal Aviation Administration (FAA), to further advance aircraft ground de/anti-icing technology.

1.1 Overview

Several research reports for testing of de/anti-icing technologies have been produced for the winter 2001-02 test program. The subject matter of these reports is described in the preface of this document. This report contains the documentation of the work conducted by APS on activities related to aircraft deicing research. Three studies are included in this report:

a) Replacement of tactile check with ground ice detection systems (GIDS): Preliminary data collection and analysis;

b) Development of test specifications for forced air deicing systems; and

c) Cooperation in the development of ground minimum operational performance specification for GIDS.

This report also contains the test procedures and presentations that were produced for the program activities conducted in 2001-02, as well as the list of the reports provided to the various manufacturers whose fluids were tested for the development of endurance times during this winter season.

The following subsections contain the background for each of the activities listed above.

1.2 Replacement of Tactile Check with Ground Ice Detection Systems: Preliminary Data Collection and Analysis

In some countries, ground deicing operators must comply with a regulated requirement to perform tactile inspections of wings of specified aircraft following deicing to ensure that no ice has adhered to the wing under the applied fluid.

GlobeGround North America (operator of the Central Deicing Facility at Toronto airport) examined the use of remote ice detection sensors during the deicing process to replace the human tactile inspection. During the winter of 2001-02, members of the APS research team developed a test procedure to be used by the operator to evaluate the effectiveness of sensors in this application, and assisted in the analysis of collected data.

Sections from the work statement that relate to this activity are provided in Appendix A.

This activity is documented in Section 2 of this report.

1.3 Development of Test Specifications for Forced Air Deicing Systems

In response to deicing operator requests, deicing vehicle manufacturers have incorporated forced air deicing systems in their deicing vehicles. These systems are generally designed to deliver a stream of air either with or without fluid. Both Type I and Type II or Type IV fluids can be delivered with the air-assist capability of various deicing trucks.

In theory, forced air can be used in several ways in a deicing operation:

a) To remove most of the contamination prior to standard deicing with heated fluid;

b) As the first step of a two-step procedure, either alone or with Type I fluid;

c) With Type I fluid as a one-step procedure; and

d) To assist in the delivery of a second-step application of Type II or Type IV fluid to achieve better reach and coverage, and to reduce fluid amounts dispensed.

The Society of Automotive Engineers (SAE) G-12 Aircraft Ground Deicing Equipment Subcommittee identified the need for an official process whereby operators could test the use of forced air assist in certain deicing applications and, based on successful outcomes, request approval from authorities to use the forced air deicing systems in operator deicing programs.

Members of the subcommittee requested the cooperation and assistance of the FAA and TC to develop an official test procedure and to define an approval process for selected applications. The two authorities agreed to the request and assigned APS to work with the Forced Air Working Group to achieve these aims.

APS has developed a test procedure for use by operators to examine whether published fluid holdover times can be used for forced air assist applications of Type II or Type IV fluid. Some operators plan to conduct tests on specific truck/fluid combinations.

A test procedure to assist operators in understanding the feasibility of using forced air with Type I fluid in a first step deicing operation has also been provided for operator implementation. Test results will indicate whether it is appropriate to examine the use of forced air with Type I fluid as a one-step process. It was concluded from previous trials in a laboratory environment on one manufacturer's system that this was not a safe application. Other systems may need to be examined. Such a study would examine the heat transfer to the wing as well as the initial fluid coverage and fluid endurance times in precipitation, and would require the involvement of experienced testers.

The work is described in Appendix A and was conducted in response to a request from the SAE G-12 Aircraft Ground Deicing Equipment Subcommittee and was approved by the FAA and TC.

This activity is documented in Section 3 of this report.

1.4 Cooperation in the Development of Ground Minimum Operational Performance Specification for Ground Ice Detection Systems

A test procedure was prepared, and tests were conducted, for a sensor manufacturer in order to evaluate compliance of its sensor with the requirements of SAE AS5116. The manufacturer funded the work, and the findings are outside the scope of this report. However a number of difficulties were experienced in the conduct of these tests. This experience provided the basis for recommendations for changes to upgrade the Standard.

Subsequently, and at the request of TC, APS conducted a demonstration for SAE/EuroCAE Working Group members of the procedures required to perform laboratory tests in accordance with SAE AS5116/ED104 Minimum Operational Performance Specification for GIDS. This demonstration, carried out at National Research Council Canada's (NRC) Climatic Engineering Facility (CEF), was undertaken to provide the participants with a better appreciation of the practicality and potential limitations of the specified tests.

APS presented a record of its experience, and recommended changes to SAE AS5116/ED104 at the SAE G-12 Ice Detection Subcommittee meeting in

Frankfurt, Germany, on June 6, 2002. The majority of the recommended changes were adopted, and the specifications have been upgraded.

A number of challenges were faced in the methodology and procedures to be followed when conducting the tests. APS also presented these issues and proposed changes to AS 5116A at the SAE G-12 Ice Detection Subcommittee meeting in Frankfurt, Germany on June 6, 2002.

This activity is documented in Section 4 of this report.

2. REPLACEMENT OF TACTILE CHECK WITH GROUND ICE DETECTION SYSTEMS: PRELIMINARY DATA COLLECTION AND ANALYSIS

This section discusses the activities related to developing operational and test data examining the possible replacement of hands-on tactile checks with GIDS.

2.1 Introduction

With the development of centralized deicing pads at airports, operators are now using radio and electronic communication methods to position aircraft, thereby eliminating personnel on the tarmac area. In addition, new truck designs with enclosed baskets have restricted the ability of the deicing operator to physically perform tactile inspections. This has led to the need for additional manpower to perform the post-deicing inspection.

GlobeGround, the operator of the Central Deicing Facility at Toronto International Airport, wished to examine the performance of remote ice detection systems with the intent of replacing the present hands-on tactile inspection. The examination process and outcome needed to demonstrate the suitability of sensors to replace tactile inspection to the satisfaction of TC, and be acceptable to the airline industry.

At the start of the winter of 2001-02, APS was asked to develop suitable procedures to be used by GlobeGround for data gathering, and to assist in the analysis of the collected data.

2.2 Methodology

In discussions between TC and GlobeGround, some guiding principles regarding data collection for this examination were agreed upon:

a) Use the remote sensors for as many deicing events as possible;

b) Record the application details and inspection findings of all aircraft deicing events (indicating whether sensors were used and whether tactile checks were conducted);

c) Maintain a paper trail back to each event so that notes on the deicing can be credited. At the end of the winter it must be possible to go back and review all aspects of an individual deicing event, including weather, prior condition of aircraft (type of contamination), aircraft type, operator identification, deicing equipment, visual findings, need to re-deice or do significant touch-ups, sensor results (as applicable), and any other comments or factors; and

d) Report the results of the observations using detailed documentation to address such issues as: Did the sensor "see" ice when it was detected by the inspector?; Were there cases when the sensor identified ice and the inspector did not?; Did the sensor see ice when in fact there was none present?

These guidelines were recognized in the developed procedures, and are included in Appendix B. Because the number of occasions that clear ice actually forms is very small, and the number of times that the deicing operation fails to clean away any clear ice is even smaller, there are very few operations where tactile inspections and ice detector systems would actually be examining ice. To compensate, the procedure included examination of the wing prior to deicing, in order to provide comparative data of how actual contamination on the wing was discerned by tactile inspection, visual inspection, and/or the ice detection system.

It was agreed with GlobeGround that a typical data package for each deicing operation would include the following:

a) Completed data forms from the test procedure;

b) GlobeGround daily statistics sheets (OPS Reports); and

c) JPEG ice detection images of the wing before and after deicing.

2.3 Activities – Winter 2001-02

During the winter of 2001-02, GlobeGround collected a limited amount of data using the supplied procedure and data forms on a number of operations. Both the Cox and Goodrich ice detection systems were employed in these trials.

The data forms completed for these operations were provided to APS, and the data were then logged and analyzed. Some data collected on GlobeGround data forms from the previous winter were also submitted and included in the analysis.

Results of the analysis were submitted to GlobeGround in early April 2002 and were presented by GlobeGround at the SAE G-12 Ice Detection Subcommittee meeting in Frankfurt in June 2002.

2.4 Conclusions and Recommendations

There were insufficient data collected to support a submission to TC. It will be necessary to collect additional data in order to have a substantial package suitable for submission for approval. To obtain more data, GlobeGround should assign a dedicated coordinator for this activity to ensure that data is collected at every opportunity.

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3. DEVELOPMENT OF TEST SPECIFICATIONS FOR FORCED AIR DEICING SYSTEMS

3.1 Introduction

During the winter of 1999-2000, APS examined safety implications of forced air deicing systems in a series of tests conducted at the NRC CEF. A Vestergaard Elephant μ deicing vehicle equipped with a forced air deicing system was used to remove various types and thicknesses of contamination from the JetStar test wing in three modes of operation: with forced air alone; with a forced air/fluid combination; and with heated fluid alone.

Test results indicated that the forced air deicing system provided neither risk of injury to personnel nor damage to aircraft any greater than current deicing methods; however, some performance shortcomings were noted. These included the failure to produce a clean wing with forced air only, and a much reduced time interval between the end of cleaning and the initial occurrence of refreezing when a forced air / Type I fluid combination was used.

At the 2001 annual SAE G-12 meeting, the Aircraft Ground Deicing Equipment Subcommittee identified the need for an official process for operators to test the use of forced air to assist in certain deicing applications and, based on successful outcomes, request approval from authorities to use the forced air deicing systems in their deicing operations. A Forced Air Working Group was nominated to work on this project on behalf of the Aircraft Ground Deicing Equipment Subcommittee.

Members of the subcommittee then requested the cooperation and assistance of the FAA and TC to develop an official test procedure and to define an approval process for selected applications. The two authorities agreed to the request and assigned APS to work with the Forced Air Working Group.

3.2 Potential Forced Air Applications

The use of forced air to assist in the deicing process has several potential applications:

a) Forced air used alone to remove most of the snow before conventional heated fluid deicing;
b) Type II or Type IV fluid either sprayed over or injected into the forced air system in a manner that allows the use of holdover time guidelines;

c) Type I fluid either sprayed over or injected into the forced air system in a manner that allows it to be used as the first step followed by an approved application of Type II or Type IV fluid as the second step;

d) Type I fluid either sprayed over or injected into the forced air system in a manner that allows it to be used as the first step followed by Type I fluid application in the second step;

e) Type I fluid either sprayed over or injected into the forced air system in a one-step de/anti-icing process that allows the use of the holdover time guidelines;

f) Type I fluid either sprayed over or injected into the forced air system to remove frost in a non-active condition; and

g) Forced air delivered alone to deice an aircraft during non-active precipitation.

Of the various potential applications, the working group gave priority to item (b).

Item (c) was given second priority.

Other potential applications have yet to be considered for the development of test procedures and the definition of the approval process.

3.3 Use of Holdover Time Guidelines for Air-Assist Type II or Type IV Fluid Application

The primary interest in this application of the forced air system lies in the possibility of an increased spray distance and improved distribution of Type II or Type IV fluids over the aircraft wing. The objective was to provide an official process for examining whether SAE Holdover Time (HOT) Guidelines could be used when SAE Type II or IV fluid is applied with the assistance of forced air.

In this application, forced air assistance can take either of two forms:

a) The fluid nozzle can be positioned above the forced air nozzle so that the fluid stream is carried on top of the air stream; or

b) The fluid nozzle can be positioned to inject fluid into the air stream so that the fluid is mixed with and carried within the air stream.

APS developed a draft test procedure and approval process that evolved through several document versions based on discussions between the Forced Air Working Group and the FAA and TC, which was finally approved.

3.3.1 Approval Process

A standard test procedure, approved by the FAA, TC, and the Forced Air Working Group, was developed to be followed by those operators interested in obtaining approval for this application. Each combination of forced air deicing truck and Type II or Type IV fluid brand requires individual testing and approval. The approved test procedure is included in Appendix D and is described briefly as follows:

a) Prior to testing the operator develops in-house air-assist spray techniques and verifies that forced air systems are operating within manufacturer specifications;

b) Operator schedules a test session and invites observers from the FAA and TC.

c) Tests are conducted on aircraft wings to measure results of fluid application using both air-assist and conventional methods. Tests include spraying into the wind and at least some tests with an outside air temperature (OAT) below freezing. Parameters tested include:

- Fluid viscosity
- Fluid thickness
- Appearance of fluid layer
    - Ridged
    - Patchy
    - Aerated
    - Contaminated

d) If the operator is satisfied with the test results, completed data forms and declaration of conformity are submitted by the operator to FAA/TC for approval on that specific truck/fluid combination; and

e) FAA/TC decision to approve is then made based on the submitted results.

3.3.2 Tests Conducted to Date

To date, the test procedures have been applied by three operators:

a) American Airlines at Chicago O'Hare International Airport, Oct. 31, 2001;

b) US Airways at Boston Logan International Airport, Nov. 15, 2001; and

c) Air Canada at Ottawa International Airport, Feb. 6, 2002.

APS participated in these tests by advising the operators about the test procedures and assisting in the data collection. The collected data remained the property of the operators involved.

Of these operators, US Airways has developed the most data and intends to complete the tests required in cold weather during the winter of 2002-03. Results of its initial tests have been documented on the SAE G-12 Aircraft Ground Deicing Equipment Subcommittee website (1). Results of tests conducted thus far indicate that application of Type II or Type IV fluid where the fluid nozzle is positioned above the forced air nozzle so that the fluid stream is carried on top of the air stream provides results similar to the conventional method of fluid application.

American Airlines has not indicated whether it will continue with testing. Results of its initial tests have not been circulated.

Air Canada has indicated that it intends to discontinue use of forced air in this specific application, as the benefits do not appear to justify the additional expense and training required.

Other operators (United Airlines, FedEx) have conducted unofficial tests, and may test with the official test procedure next winter.

3.4 Type I Fluid Application with Forced Air as the First Step in a Two-Step Procedure

The objective was to provide a test procedure to assist operators in examining whether Type I fluid applied with air-assist can be used safely as the first step of a two-step process when followed with an application of Type II or Type IV anti-icing fluid.

In a two-step deicing operation, it is a safety requirement that the wing surfaces (or other critical surfaces) remain free of contamination after deicing, until the second step anti-icing fluid is applied. SAE ARP4737 (2) gives a 3-minute guideline as the time that the surface might be expected to remain uncontaminated. However, this is only a guideline, and the deicing operator is always responsible for ensuring that the surfaces are still uncontaminated when the anti-icing fluid is applied.

Two factors control the time to refreeze: the freeze point of the fluid on the wing and the wing surface temperature.

The fluid freeze point is influenced by:

a) Initial freeze point of the fluid (limit of OAT + 3°C);

b) Initial thickness of the fluid layer on the wing;

c) The rate of precipitation; and

d) The local geometry of the wing surface (which affects the rate of run-off and fluid feed from other areas).

The wing surface temperature is influenced by:

a) Initial wing temperature;

b) Fluid temperature;

c) Quantity of fluid applied;

d) Operator technique;

e) OAT;

f) Wind;

g) Cooling from precipitation; and

h) Fuel quantity and temperature.

3.4.1 Approval Process

As mentioned above, the requirement to maintain a clean wing until the second step anti-icing fluid was applied was a fundamental responsibility of the deicing operator, regardless of the method of cleaning the aircraft surface. Because the fluid endurance time was irrelevant in this application, it was concluded that approval of the two authorities (FAA and TC) was not needed, but that the operator should decide whether the proposed use of the forced air system was satisfactory. The following requirements would have to be met:

a) A clean surface is produced;

b) The surface remains uncontaminated long enough to allow the second step to be accomplished before the first step can freeze;

c) Slush is not pushed into wing cavities by the air stream; and

d) There is no danger of the flying snow and ice being ingested into the aircraft engines.

If, after testing, the operator was satisfied that the forced air-assist deicing procedure met the requirements, then the operator could decide to use it as a standard procedure. To support operator decision-making, it was suggested that the results of independent operator tests be shared among the various interested operators.

3.4.2 Test Procedure

The approved test procedure is included in Appendix E. The following is a summary of the test requirements:

a) Each combination of forced air deicing truck and Type I fluid brand requires individual testing;

b) When sufficient information has been gathered for a range of conditions, then an operator decision can be made; and

c) Results of tests conducted in mild conditions are not applicable in more severe conditions.

Procedures and training for operators to follow would include:

a) The definition of acceptable weather limits for this application of the forced air deicing system (based on test experience); and

b) An emphasis on deicing operator responsibility for ensuring that the deiced surfaces are still uncontaminated when the anti-icing fluid is applied.

3.4.3 Tests to Date

No tests using the test procedure have been conducted yet. US Airways has expressed an interest in conducting tests next winter.

4. COOPERATION IN THE DEVELOPMENT OF GMOPS FOR GIDS

4.1 Demonstration of Ice Detection Trials

4.1.1 Introduction

A test procedure was prepared and tests were conducted for a sensor manufacturer in order to evaluate compliance of its sensor with the requirements of SAE AS5116. The manufacturer funded the work, and the findings are outside the scope of this report; however, a number of difficulties were experienced in conduct of the tests. This experience provided the basis for recommendations for changes to upgrade the Standard.

Subsequently, and at the request of TC, APS conducted a demonstration for SAE/EUROCAE Working Group members of the procedures required to perform laboratory tests in accordance with SAE AS5116/ED104 Minimum Operational Performance Specification for GIDS. This demonstration, carried out in the NRC CEF, was undertaken to facilitate an appreciation of the practicality and potential limitations of the specified tests.

APS presented a record of its experience, and recommended changes to SAE AS5116/ED104 at the SAE G-12 Ice Detection Subcommittee meeting in Frankfurt, Germany, on June 6, 2002. The majority of the recommended changes were adopted, and the specifications have been upgraded.

A number of challenges were faced in the methodology and procedures to be followed when conducting the tests. APS also presented these issues and proposed changes to AS 5116A at the SAE G-12 Ice Detection Subcommittee in Frankfurt, Germany, on June 6, 2002.

4.1.2 List of Demonstrations

The members of the working group were first given a tour of NRC. Following is a list of the demonstrations presented by APS to the working group over the two-day period:

a) Ice disc making;
b) Frost making;
c) Precipitation rate measurement;

d) Fluid failure call for freezing drizzle;

e) Fluid failure call for snow using the NCAR snowmaker; and

f) Freezing fog visibility.

A copy of the demonstration schedule and the details of the demonstration are contained in Appendix F.

4.1.3 Publication of GMOPS Document

The GMOPS document was accepted by the Council of EUROCAE in November 2001 as ED 104 and by SAE in February 2002 as GMOPS AS 5116A (3).

4.2 Revisions to GMOPS AS5116A

4.2.1 Introduction

During 2001, an agreed standard procedure was prepared for a sensor manufacturer to test its remote GIDS. AS 5116A was used as a guideline for preparing the test procedure. A number of challenges were faced in the methodology and procedures to be followed when conducting the tests. These challenges led APS to present the issues and propose changes to AS 5116A first in a document entitled "Proposed Revisions to AS 5116A", dated May 2, 2002. This document was posted for members of the SAE G-12 Ice Detection Subcommittee to review prior to the June 2002 meeting in Frankfurt, Germany. Comments and questions were received and addressed by APS.

During the meeting, the proposed changes were presented. After extended discussions and with the consensus of the members of the subcommittee that were present, changes were made to the document.

4.2.2 Presentation

A copy of the presentation to the Ice Detection Subcommittee of the proposed changes to AS 5116A is provided in Appendix G. Appendix G also contains a list of all the presentations that were made by APS during the SAE G-12 meetings in Frankfurt, Germany, in June 2002.

Due to the nature of the tests required by the sensor manufacturer, the changes proposed by APS involved several issues in the following domains:

a) Section 5 of AS 5116A;

b) Frozen contamination detection and visibility tests; and

c) Remote ground ice detection.

Following is a brief list of the tests that presented procedural and methodological challenges and the associated changes proposed by APS. These items were addressed by APS and were discussed during the meetings in Frankfurt (Appendix G contains the details):

1. Contaminated surface treated with fluid after deicing

   - This was a technical and a procedural challenge. Tolerances were added to parameters and text that further elaborated the procedure was added.

2. Frozen contamination above the detection threshold

   - Text that further elaborated the procedure was added.

3. Fog visibility tests

   - The temperature of the water supply of the spray equipment was modified.

4. Snow visibility tests

   - The air temperature requirement was modified.

5. Freezing drizzle and light freezing rain visibility tests

   - The precipitation rate tolerances for both conditions were modified, and a new designation was created for each of the two conditions.

6. Angle of test plate

   - APS proposed that the angle requirement of the test plate be modified. All tests are to be conducted while plates are placed at a 10° angle to the horizontal. Tests conducted on the GIDS whose maximum distance and minimum angle are such that the physical limitations of the test chamber will not accommodate the distances and heights may require that the test plates be placed at varying angles. This also holds true for tests conducted outdoors where physical limitations dictate that the test plates be placed at angles greater than 10°. The members of the subcommittee that were present did not accept this proposed change; they indicated that the sensor manufacturer can still carry out tests at different angles and report those angles.

4.2.3 Publication of Upgraded AS5116

SAE AS 5116 and ED 104 were revised to include the recommended changes.

A document entitled "Explanation of Revisions to AS 5116A" was provided by APS to explain the changes. This document contains a list of the changes proposed during the meeting, and which pertain to items raised by APS, as well as the justification related to those changes. The changes listed also reflect the recommendations and approval of the members of the subcommittee that were present. A copy of this document is contained in Appendix F.

5. PROCEDURES, PRESENTATIONS, AND FLUID MANUFACTURER REPORTS

5.1 Procedures

Several procedures were developed to guide and support the research team in the methodology for conducting trials. Table 5.1 provides a list of the procedures developed to address specific projects, which are also identified in the table. The actual procedures have been included in respective reports of the overall research program.

5.2 Presentations

During the course of a research program, subcommittees of the SAE G-12 Committee hold several meetings. During these meetings, APS presents the findings of the work that has been completed. Much of the research presented at these meetings is eventually documented in various reports.

In 2001-02, four meetings were held:

1. SAE G-12 HOT Subcommittee Meeting, Montreal, November 2001;
2. SAE G-12 HOT Subcommittee Working Group Meeting, Montreal, May 2002;
3. SAE G-12 Committee, Aircraft Ground Deicing Meetings, Frankfurt, June 2002; and
4. Summer Winter Integrated Field Technologies (SWIFT) Conference, Calgary, September 2002.

The presentations given by APS at each of these meetings are listed in the following subsections. A copy of each presentation is contained in Appendix G.

5.2.1 SAE G-12 Holdover Time Subcommittee Meeting, Montreal, November 2001

Two presentations were prepared for the SAE G-12 HOT Subcommittee meeting held in Montreal November 29-30, 2001:

Table 5.1: List of Procedures for Winter 2001-02

Contract Task		Name of Procedures	Date of Latest Version	Versions submitted to TDC	Status
1.1	HOLDOVER TIME TESTING AND EVALUATION OF DE/ANTI-ICING FLUIDS	Experimental Program for Dorval Natural Precipitation Flat Plate Testing	09-Oct-01	1.0	TDC
1.1	HOLDOVER TIME TESTING AND EVALUATION OF DE/ANTI-ICING FLUIDS	Detailed Plan of NRC Cold Chamber Testing	03-Apr-02	1.0	TDC
1.3	HOT TESTS IN FROST	Phase I Evaluation of Frost Accretion Rates in Natural Condition	13-Nov-01	1.0	TDC
1.3	HOT TESTS IN FROST	Phase II Validation Tests in Conjunction with Aircraft Wings	13-Nov-01	1.0	TDC
1.3	HOT TESTS IN FROST	Phase III Evaluation of Wing-To-Air Temperature Differential	13-Feb-02	1.0	TDC
1.3	HOT TESTS IN FROST	Phase IV Experimental Procedure for Holdover Time Testing in Simulated Frost Conditions	13-Feb-02	1.0	TDC
1.6	EVALUATION OF WINTER WEATHER DATA	Experimental Procedure for the Collection of Fog Rates of Deposition in Natural Conditions	09-Nov-00	1.0	TDC
1.7	DOCUMENTATION OF FLUID FAILURE CHARACTERISTICS	Procedure for the Documentation of the Appearance of Failed Fluids for Outdoor Tests	09-Nov-01	1.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	ET Tests on Cold-Soak Boxes at Quebec City Airport	23-Jan-02	n/a	APS files
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Examination of Fluid Quantities for SAE Type I Fluid Endurance Laboratory Test Procedure	07-Sep-01	1.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Field Trials for Type I HOT Test Protocol	21-Nov-01	1.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Determination of Outdoor Endurance Times of Type I Fluids Using the New Test Protocol	09-Jan-02	1.1 & 2.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Potential Use of Protocol for Type II and IV Fluid Dilutions	09-Jan-02	1.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Examine Use of 60°C Fluid and a Cold-Soak Box as Test Surface for SAE Type I Fluid Endurance Laboratory Tests	22-Nov-01	1.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Determination of Indoor Endurance Times of Type I Fluids Using the New Test Protocol	10-Dec-01	1.0 & 1.1	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Determination of Indoor Endurance Times of Type I Fluids Using the New Test Protocol and an Adjusted Air Temperature	19-Feb-02	1.0	TDC
2	DEVELOPMENT OF PROTOCOL FOR TYPE I TESTING	Addendum One ET Times of Dilute Heated Type II/IV Fluids Measured by the New Test Protocol and an Adjusted Air Temperature	04-Mar-02	1.0	TDC
3	FLOW OF CONTAMINATED FLUID	Field Trials to Examine Removal of Diluted Fluid from Aircraft Wings During Takeoff Run	28-Feb-02	1.0	TDC
3	FLOW OF CONTAMINATED FLUID	Field Trials to Examine Removal of Diluted Fluid from Aircraft Wings During Takeoff Run	04-Mar-02	2.0	TDC
4	MEASURE OF ON-WING VISCOSITY	Viscosity Measurements of Fluids	03-Apr-02	1.0	TDC
6	NCAR SNOWMAKER	Trials to Determine the Differences between Natural Snow and the NCAR Snow Generation System - Outdoor	08-Jan-02	1.0	TDC
6	NCAR SNOWMAKER	Trials to Assess the Performance of the NCAR Snow Generation System	03-Apr-02	1.0	TDC
6	NCAR SNOWMAKER	Trials to Measure the Uniformity of Outdoor Snow Precipitation Rates	26-Oct-01	1.0	TDC
7.1	REPLACEMENT OF TACTILE CHECK WITH GIDS	Evaluation of GIDS Sensors to Replace Tactile Inspections	06-Dec-01	1.0	e-mailed to Frank Eyre
7.1	REPLACEMENT OF TACTILE CHECK WITH GIDS	Meteo Data Form	16-Mar-01	1.0	e-mailed to TC, GG & MFG
8	CONTAMINATION OF WINGS AT END-OF-RUNWAY	Field Trials to Determine the Extent of Contamination on Departing Aircraft	28-Feb-02	1.0	TDC
10	SUPPORT SERVICES	Overall Program of Tests at NRC - April, 2002	03-Apr-02	1.0	TDC
10	SUPPORT SERVICES	Experimental Program to Establish Film Thickness Profiles for Deicing and Anti-icing Fluids on Flat Plates - NRC CEF	03-Apr-02	1.0	TDC
10	SUPPORT SERVICES	Preliminary Evaluation of IR Thermometers to Assist in Identifying Ice on Wings after Deicing	10-Sep-01	1.0	TDC
10	SUPPORT SERVICES	Type II / IV Fluid Applied into Forced Air Stream	These procedures were created in 2000-01. The testing may continue in 2001-02.		
10	SUPPORT SERVICES	Type I Fluid Applied or Injected into Forced Air Stream			

M:\Groups\Cm1680 (01-02)\Reports\Support Services\Working Documents\Table 5.1 List of Procedures

1. Holdover Times for Forced Air Applications; and
2. Effect of Fluid Strength and Dilution Rates on SAE Type I Fluid Endurance Times.

5.2.2 SAE G-12 Holdover Time Subcommittee Working Group Meeting, Montreal, May 2002

Two presentations were prepared for the SAE G-12 HOT working group meeting in Montreal in May 2002:

1. Type I Fluid Endurance Time Tests Using New Protocol; and
2. Type I Fluid Endurance Time Tests at -3°C.

5.2.3 SAE G-12 Committee, Aircraft Ground Deicing Meetings, Frankfurt, June 2002

Eight presentations were prepared for the SAE G-12 meetings in Frankfurt from June 2-7, 2002, as follows:

1. Aircraft De/Anti-Icing Fluid Endurance Time Results from 2001-02 Tests (for HOT Subcommittee); Type I Fluid Endurance Time Tests Using New Protocol (for HOT Subcommittee); Frost Contamination – Countermeasure Development Opportunities (for Future Technologies Subcommittee);
4. Test Program - Forced Air Systems Type II or Type IV Fluid Applied Over or Injected into the Forced Air Stream (for HOT Subcommittee);
5. Test Program - Forced Air Systems Type II or Type IV Fluid Applied Over or Injected into the Forced Air Stream (for Equipment Subcommittee);
6. Test Program - Forced Air Systems Type I Fluid Applied Over or Injected into the Forced Air Stream (for Equipment Subcommittee);
7. Operational Guidelines for On-Wing Thickness of SAE Type II or Type IV Fluids (for HOT and Methods Subcommittee); and
8. Proposed Revisions to AS 5116A (for Ice Detection Subcommittee).

A presentation was prepared for the SWIFT conference at Calgary, Alberta in September 2002:

- Aircraft Deicing with Forced Air.

5.3 Fluid Manufacturer Reports

As part of the research program, several fluids are tested for holdover time performance every year. Some of this data is then published for holdover time use in the industry, while some of the data for some fluids that are tested is maintained by the fluid manufacturer for research purposes. During the winter of 2001-02, a total of 10 fluids were tested. Fluid manufacturer reports containing the test results were published for all 10 fluids. In addition, endurance time data for four of these fluids are being published in TC report TP 13991E, *Aircraft Ground De/Anti-icing Fluid Holdover Time and Endurance Time Testing Program for the 2001-02 Winter,* (4). Following is a list of all fluids tested:

1. Clariant Safewing MPIV 2001 (Degraded);
2. Clariant Safewing MP II 2025 LITE;
3. Kilfrost ABC 2000 Type II (also published in TC report TP 13991E (4));
4. Kilfrost P1064 Type IV;
5. Octagon E MAX II (also published in TC report TP 13991E (4));
6. DOW (UCAR) T4 Type IV;
7. DOW (UCAR) 20-MJM-66;
8. DOW (UCAR) PG ADF Type I (also published in TC report TP 13991E (4));
9. HOC Safetemp Type I; and
10. SPCA DE-950 Type I (also published in TC report TP 13991E (4)).

REFERENCES

1. http://www.sae.org/servlets/index, Society of Automotive Engineers (SAE).

2. Society of Automotive Engineers (SAE) Aerospace Recommended Practice ARP4737 (Rev. E), *Aircraft Deicing/Anti-icing Methods with Fluids*, Warrendale, PA, December 2001, 30.

3. Society of Automotive Engineers (SAE) Aerospace Standard AS 5116, *Aerospace Standard / Minimum Operational Performance Specification for Ground Ice Detection Systems*, Warrendale, PA, May 2001, 45.

4. Chaput, M., Campbell, R., *Aircraft Ground De/Anti-Icing Fluid Holdover Time and Endurance Time Test Program for the 2001-02 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2002, TP 13991E (to be published).

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APPENDIX A

TERMS OF REFERENCE – PROJECT DESCRIPTION
EXCERPTS FROM TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENTS

Work Statement Index

This appendix contains excerpts from work statements that relate to the following activities:

Support for Replacement of Tactile Check with Ground Ice Detection Systems

The excerpt from TDC Work Statement DC202 is relevant to the work that is being reported.

Test Specifications for Forced Air De-icing Systems

The excerpt from TDC Work Statement DC187 is relevant to the work that is being reported.

Ice Detection – Demo & Revisions

The excerpt from TDC Work Statement DC187 is relevant to the work that is being reported.

Support for Replacement of Tactile Check with Ground Ice Detection Systems

Excerpt from
Transportation Development Centre

Work Statement - DC 202
Aircraft & Anti-Icing Fluid Winter Testing
Winter Operations Contaminated Aircraft - Ground
2001-2003
(March 2002)

5.16 Support for Replacement of Tactile Check with GIDS

5.16.1 Retrieve data from GlobeGround following the de-icing season, or the end of the data collection period, and analyze the data to compare the effectiveness of Remote Ground Ice Detection System (GIDS) indications versus tactile inspection;

5.16.2 Develop a report; and

5.16.3 Review the results with all parties.

Test Specifications for Forced Air De-icing Systems

Excerpt from
Transportation Development Centre

Work Statement -- DC 187
Aircraft & Anti-Icing Fluid Winter Testing
2000-2001
(March 2002)

5.9.1 Test Specification for Forced Air De-icing Systems

Background

Airlines have shown increased interest in the use of forced air de-icing to clean frozen contaminants from aircraft surfaces, corresponding to the development by several manufacturers of forced air systems mounted on conventional de-icing vehicles. It is expected that a number of airlines will employ forced air de-icing systems during the 2000-01 winter season.

During the 1999-2000 winter season, safety implications of forced air systems were examined in a series of tests at the NRC Climatic Engineering Facility. A Vestergaard forced air system installed on a Vestergaard Elephant de-icing vehicle was tested. Freezing rain, and dry and wet snow contamination was removed from the JetStar test wing by blown air, blown air/fluid mix, and by standard application of heated fluid.

Test results indicated that the forced air de-icing system tested did not offer risk of injury to personnel or damage to aircraft any greater than current de-icing methods using heated fluid. However, some performance shortfalls were noted. These included the failure to produce a clean wing surface when using forced air alone, and a much reduced interval between end of cleaning and initial occurrence of refreezing when de-icing with a forced air / injected Type I fluid mix.

5.9.1.1 Develop test specifications for evaluating the safety of forced air systems, and the operational acceptability in performing either step of a 2-step operation or a complete one-step de-icing operation;

5.9.1.2 These test specifications should include examination of:

a) Noise intensity generated by the forced air equipment;

b) Effect on visibility when removing snow and ice;

c) The tendency to dislodge chunks of snow or ice and to fling them some distance and height;

d) Pressure exerted on the skin of the aircraft;

e) Effect on aircraft skin temperature;

f) Elapsed time following de-icing before refreezing occurs;

g) Residue in quiet areas;

h) The condition and thickness of the Type I fluid layer remaining on the wing following application with a fluid/air combination nozzle; and

i) The condition, thickness and viscosity of Type IV fluid (applied with a fluid/air combination nozzle) remaining on the wing during the holdover time phase.

5.9.1.3 Involve selected airline representatives in the development of the draft specification to provide feedback and to ensure all operational concerns are addressed;

5.9.1.4 Present the proposed test protocol to the SAE Ground De-icing Equipment at a working group meeting and at the annual G-12 meeting in May 2001; and

5.9.1.5 Prepare a report.

Ice Detection – Demo & Revisions

Excerpt from
Transportation Development Centre

Work Statement - DC 187
Aircraft & Anti-Icing Fluid Winter Testing
2000-2001
(March 2002)

5.9.3 Ice Detection – Demo & Revisions

Hold a demonstration of the procedures required to conduct laboratory trials for evaluating the minimum operational performance requirements of ice detection sensors. This will introduce the working group members of the SAE to the procedures that would be used to carry out the tests and the nature of the challenges that may be faced at the facility. A second objective is to expose the working group to the capabilities of the facility.

In addition, recommend changes to the GMOPS AS 5116 A to the Ice Detection Subcommittee.

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APPENDIX B

EXPERIMENTAL PROGRAM
EVALUATION OF GIDS SENSORS TO REPLACE TACTILE INSPECTIONS

EVALUATION OF GROUND ICE DETECTION SENSORS TO REPLACE TACTILE INSPECTIONS

1. PROCEDURE FOR COMPLETING DATA FORMS

1.1 Ice Detection Data Sheet – Form 1 (Figure B-1)

This form is completed by the GIDS camera operator. A separate form is completed for each aircraft deicing operation scanned by the GIDS camera.

1.1.1 General Information

Enter information as shown in the form. The 2nd Tactile Inspector is required when the camera has indicated contamination, but the 1st tactile inspection has not found any contamination.

1.1.2 Weather

Circle the appropriate weather condition.

1.1.3 Deicing Operation

Record information as shown to identify the specific deicing operation.

1.1.4 Condition before Deicing

Visual	Indicate the area where visual contamination exists, by outlining the area(s) on the aircraft sketch. Circle the type of contamination in the box at the bottom of the form.
Tactile	Indicate whether a tactile inspection was performed by circling Y (yes) or N (no). Note the results of the tactile inspection.
Camera	Indicate whether the camera detected contamination by circling Y or N. Record the distance to and height above the target being viewed.

1.1.5 Condition after Deicing

Record the condition of the wing after deicing. Indicate by circling Y or N, whether ice was detected visually, by the tactile inspection, or by the camera.

If the camera detected ice and the tactile inspection did not, then call a 2nd inspector to examine for ice.

If either the 1st or 2nd tactile inspection detects ice, then complete the details on Form 2.

1.2 Ice Detection Data Sheet – Form 2 (Figure B-2)

This form is used to record details of any ice detected by tactile inspections.

1.2.1 Deicing Operation

Complete details in this box to identify the specific deicing operation and Tactile Inspector recording the data.

1.2.2 Mark on Wings where Ice Was Located

Outline the area(s) on the wing(s) where ice was detected by the tactile inspection.

1.2.3 Estimate Ice Thickness

An effective way to estimate ice film thickness is to compare it to the thickness of a dime (averaging about 1 mm). The current GIDS threshold for ice thickness is 0.5 mm.

Some of the ice will need to be removed down to the wing surface. Lay the dime on the surface next to the remaining ice and judge whether the ice is thinner, thicker, or about the same as the dime.

1.2.4 Estimate Size of Iced Area

Extreme accuracy is not needed for this estimate. A convenient way to judge the iced area is to compare it to the size of the data form. An 8.5 x 11 sheet is about 600 cm^2. The current GIDS threshold for iced area is 315 cm^2 (about ½ a sheet of paper).

Using the data form as a guide, estimate the size of the iced area and record the estimate as indicated.

Alternatively and particularly if the area is large, estimate the length and width of the iced area (in feet) and record.

1.2.5 What Was Wing Finish

Record the kind of wing finish where the tactile inspection detected the ice. Record whether the wing was bare aluminum, or painted and what colour.

Figure B-1
ICE DETECTION DATA SHEET – FORM 1

General Information

Camera Type ________________ Camera Serial # __________________

Truck Serial # __________________ Camera Operator ________________

Tactile Inspector #1 _________________ Tactile Inspector #2 (note 1) ___________

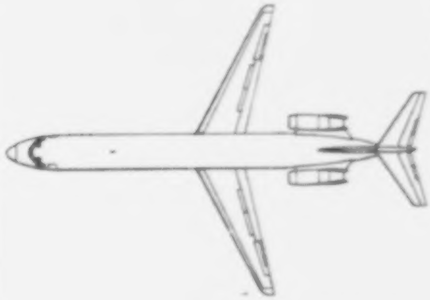
Date ________________________

Weather (Circle applicable conditions) **Temperature** ___°C

Light Snow	Moderate Snow	Heavy Snow
Light Freezing Rain	Moderate Freezing Rain	Heavy Freezing Rain
Light Rain	Moderate Freezing Rain	Heavy Rain
Freezing Drizzle	Freezing Fog	Fog
Overcast	Partly Sunny	Sunny
Night	Other Freezing Conditions __________________________	

Deicing Operation

Aircraft: Type ________ Airline __________ Fin ________ Time___________



Condition Before Deicing

Visual:-mark contaminated areas on a/c sketch

-circle type of contamination below

Tactile: - performed? Y or N

-results ______________

Camera: -detect contamination? Y or N

-distance to target ____ ft

-height above target ____ft

Condition After Deicing	Tactile Inspector #1	Tactile Inspector #2 (see note 1)
Visual – Detect Ice?	Y or N	
Tactile – Detect Ice?	Y or N	Y or N
Camera – Detect Ice?	Y or N	

Note 1: If Camera detects ice but Tactile does not, repeat Tactile with 2nd Inspector.

Note 2: If Tactile detects ice either in 1st or 2nd inspection, complete Data Sheet 2.

Contamination Types (Circle applicable)

No Contamination Frost Snow Ice Slush

Other Frozen Contamination

Figure B-2
DESCRIPTION OF ICE FOUND IN TACTILE TEST AFTER DEICING
FORM 2

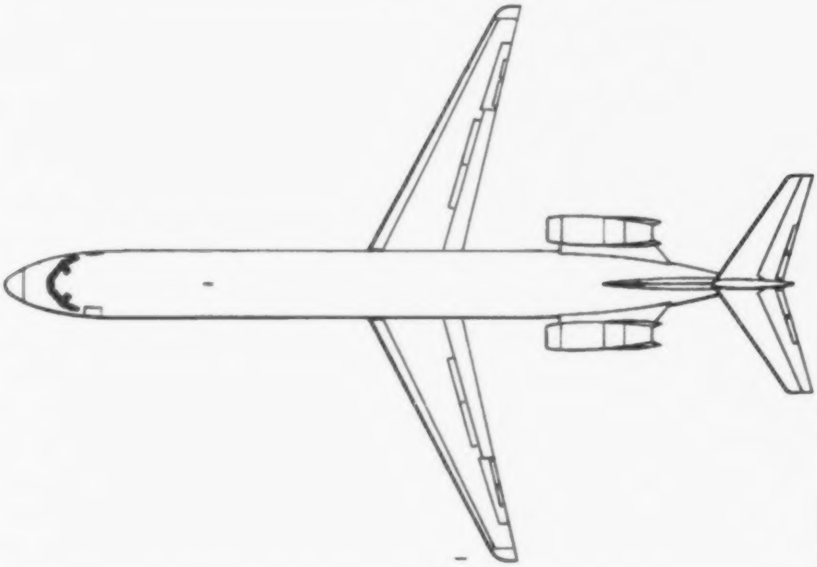
This form is used to record the details of ice detected by tactile test after deicing, whether or not the ice is detected by the camera.

Deicing Operation

Aircraft Type ____________ Airline____________ Fin ____________

Date _______Time _______ Tactile Inspector ________________________

Mark on wings where ice was located.



Estimate ice thickness using a dime as reference (a dime thickness = 1.0 mm).

Thinner than a dime __________

About the same as a dime __________

One to two dimes in thickness__________

Thicker than two dimes __________

Estimate size of iced area:

Method 1: compare iced area to the size of a sheet of paper (data form)

½ sheet _____ 1 sheet _____ 2 sheets ___

how many sheets?_____

Method 2: estimate of iced area length ______ inch x width ______ inch

What was wing finish? aluminium ☐

painted ☐ colour _________

APPENDIX C

EXPERIMENTAL PROGRAM
GENERAL PROCEDURE PROPOSED FOR TACTILE TESTS

Experimental Program – General Criteria Used for Tactile Test Design

The following is a listing of the general criteria that has been used to design the tests to be conducted at Toronto. The purpose of these tests is to compare the conditions observed using the two remote sensors to what is observed by ground personnel using the normal tactile procedures. These tests are intended to supplement the testing that is being run by Hudson General during live operations.

A matrix of tests showing the content of each test scenario is attached, together with sketches of each scenario.

1. Shapes (objects) of contamination are described below and based on GMOPS values of 0.5 mm and 315 cm^2
   - 3 thicknesses selected (aim for midpoint when creating thickness)
     1. 0.05 to 0.2 mm
     2. 0.3 to 0.5 mm
     3. 0.5 to 0.7 mm
   - 4 areas selected
     1. 100 cm^2 (size of ice catch plate)
     2. 200 to 300 cm^2 (size of WSET and frost plate)
     3. 400 to 600 cm^2
     4. 1000 to 2000 cm^2 (size of standard HOT test plate)
2. 20 scenarios will be created
   - 8 with no contamination (2 day, 5 night, 1 spare)
   - 12 with contamination
3. 2 of the 12 contamination scenarios will have full wing ice (one less than 0.5 mm, other more than 0.5 mm)
4. 2 of the 12 contamination scenarios will have area$<$315 cm^2 and $t<.5$ mm
5. 2 of the 12 contamination scenarios will have area$>$315 cm^2 and $t<.5$ mm
6. 2 of the 12 contamination scenarios will have area$<$315 cm^2 and $t>.5$ mm
7. 4 of the 12 contamination scenarios will have area$>$315 cm^2 and $t>.5$ mm
8. One scenario that has ice in daytime (15) will be repeated after darkness sets in (16)
9. Wing sectioned into 3 areas (inboard, mid, outboard)
10. Maximum number of objects/section of wing is 2; this number of objects and the object itself is randomly selected based on the previous criteria
11. Sequence of tests is random except in logical order to facilitate testing (eg. day to night transition should use same scenario as previous test)
12. One repeat test (tests 19 and 20)

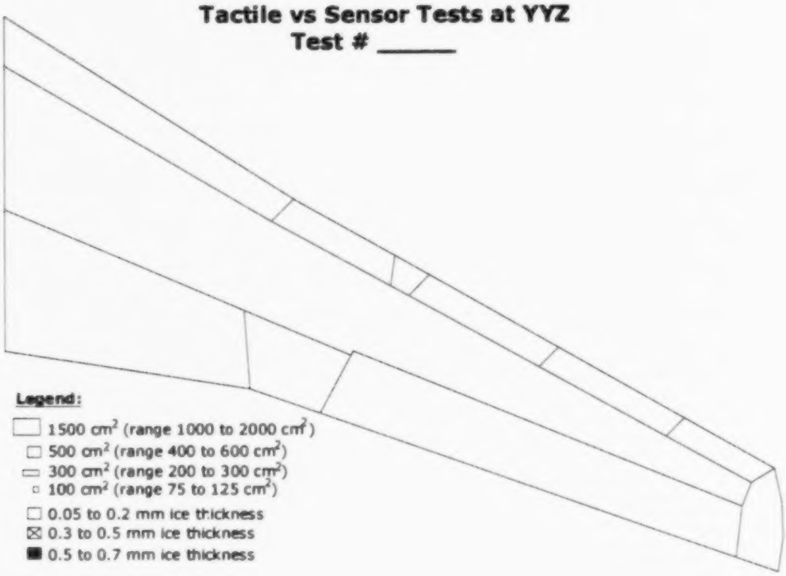
Matrix of Tactile vs. Sensor Tests at YYZ

Test #	Condition	Day Test	Night Test	Comments
1	*SPARE -TBD*	X		
2	Bare Wing	X		
3	Bare Wing	X		
4	Bare Wing	X		
5	Bare Wing		X	
6	Bare Wing		X	
7	Bare Wing		X	
8	Bare Wing		X	
9	Full Ice (thick. < 0.5 mm)		X	
10	Full Ice (thick. > 0.5 mm)	X		
11	Area < 315cm^2 & ice thickness < 0.5mm	X		
12	Area < 315cm^2 & ice thickness < 0.5mm	X		
13	Area > 315cm^2 & ice thickness < 0.5mm	X		
14	Area > 315cm^2 & ice thickness < 0.5mm	X		
15	Area < 315cm^2 & ice thickness > 0.5mm	**X**		These two tests are identical and sequential
16	Area < 315cm^2 & ice thickness > 0.5mm		**X**	
17	Area > 315cm^2 & ice thickness > 0.5mm	X		
18	Area > 315cm^2 & ice thickness > 0.5mm		X	
19	Area > 315cm^2 & ice thickness > 0.5mm	**X**		These two tests are identical and sequential
20	Area > 315cm^2 & ice thickness > 0.5mm	**X**		

Schedule of Tactile vs. Sensor Tests at YYZ

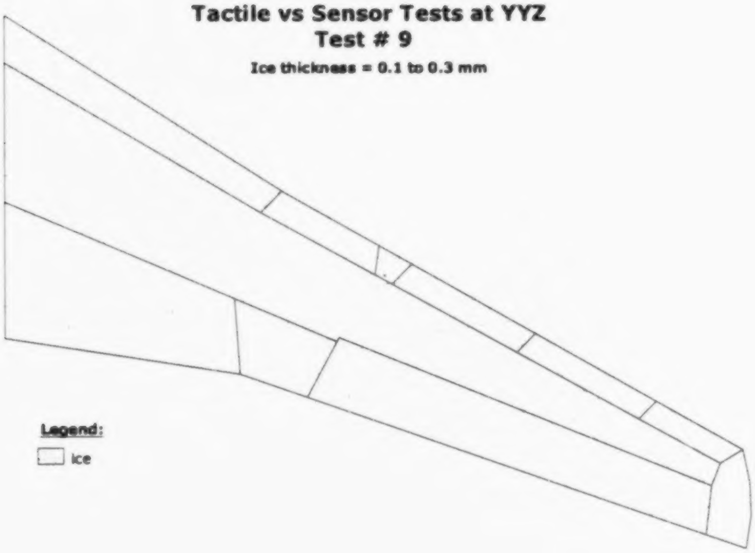
Time	TEST #				Comments
	Day 1	Day 2	Day 3	Day 4	
8:30 to 11am	3	17	2	10	Day tests
11am to 1:30pm	19	4	14	13	
1:30am to 4pm	20	15	12	11	
4pm to 6:30pm	7	16	18	5	Night Tests
6:30pm to 9pm	9	8	6		

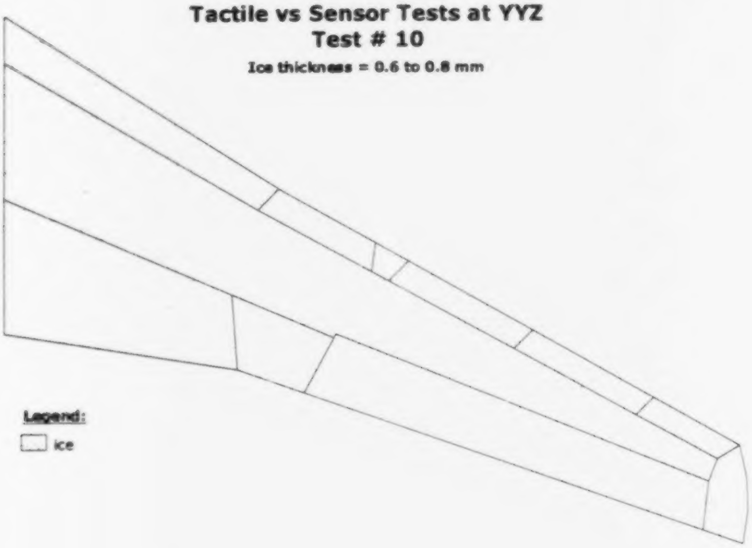
Tactile vs Sensor Tests at YYZ
Test # ______


Legend:
1500 cm² (range 1000 to 2000 cm²)
500 cm² (range 400 to 600 cm²)
300 cm² (range 200 to 300 cm²)
100 cm² (range 75 to 125 cm²)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness

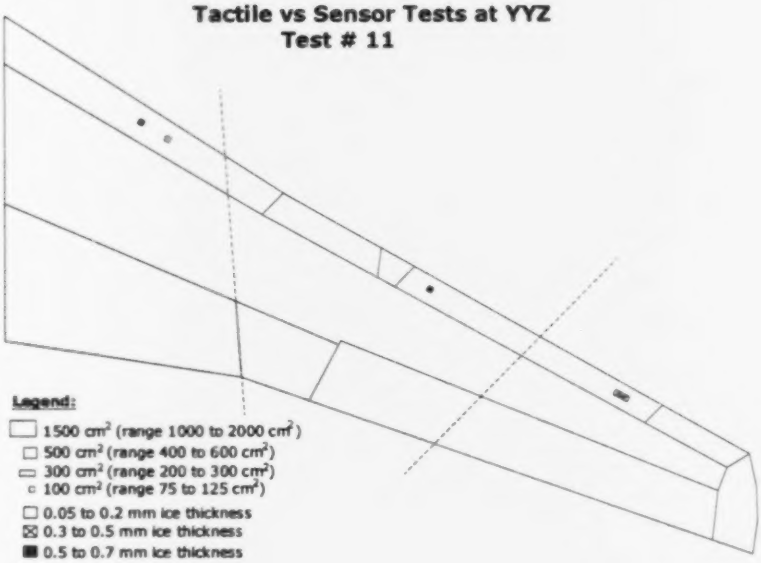
Tactile vs Sensor Tests at YYZ
Test # 9

Ice thickness = 0.1 to 0.3 mm





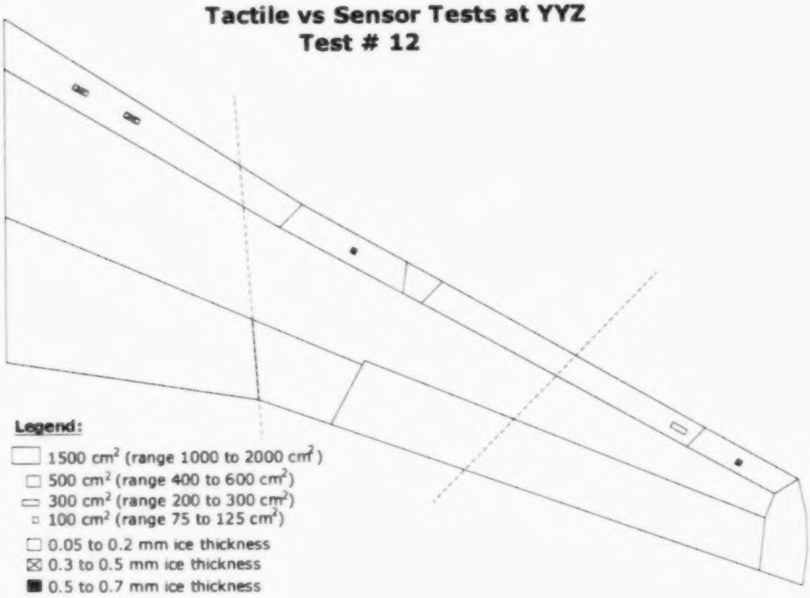
Tactile vs Sensor Tests at YYZ
Test # 10
Ice thickness = 0.6 to 0.8 mm



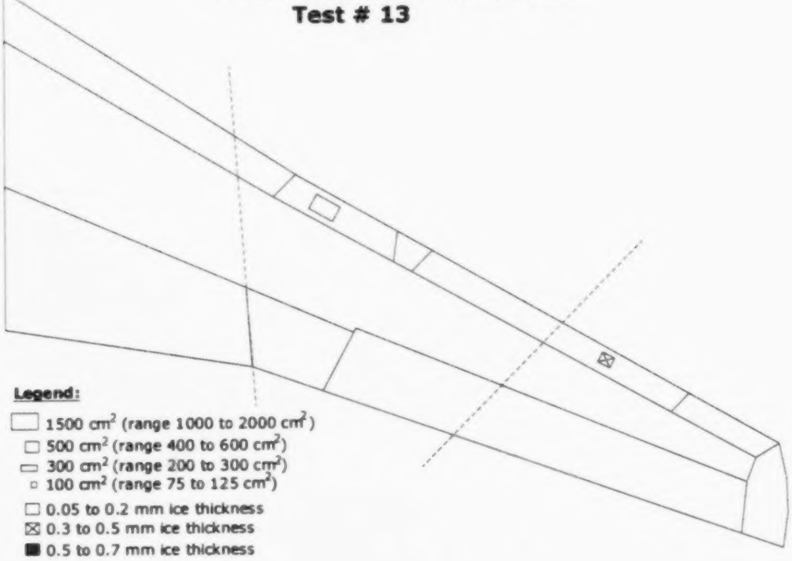
Tactile vs Sensor Tests at YYZ
Test # 11

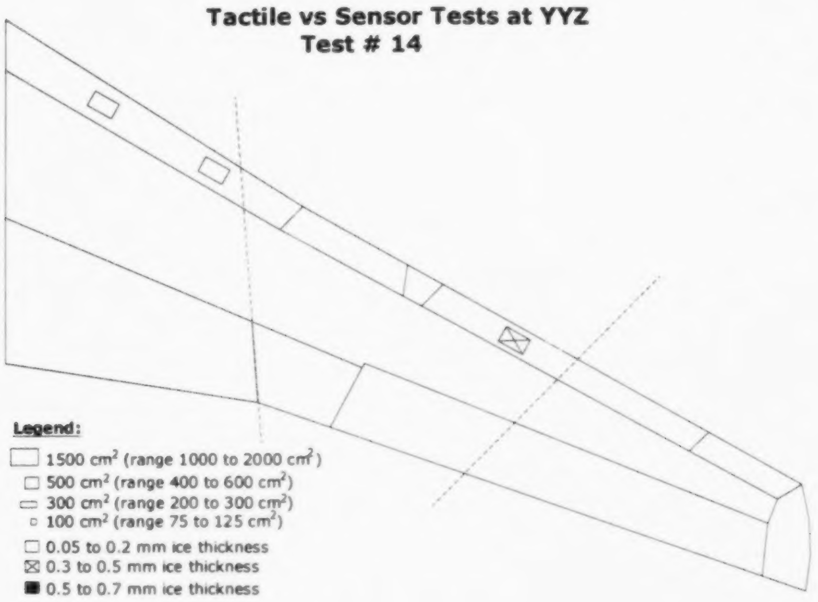
Legend:
1500 cm² (range 1000 to 2000 cm²)
500 cm² (range 400 to 600 cm²)
300 cm² (range 200 to 300 cm²)
100 cm² (range 75 to 125 cm²)
0.05 to 0.2 mm ice thickness
0.3 to 0.5 mm ice thickness
0.5 to 0.7 mm ice thickness

Tactile vs Sensor Tests at YYZ
Test # 12


Legend:
1500 cm^2 (range 1000 to 2000 cm^2)
500 cm^2 (range 400 to 600 cm^2)
300 cm^2 (range 200 to 300 cm^2)
100 cm^2 (range 75 to 125 cm^2)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness

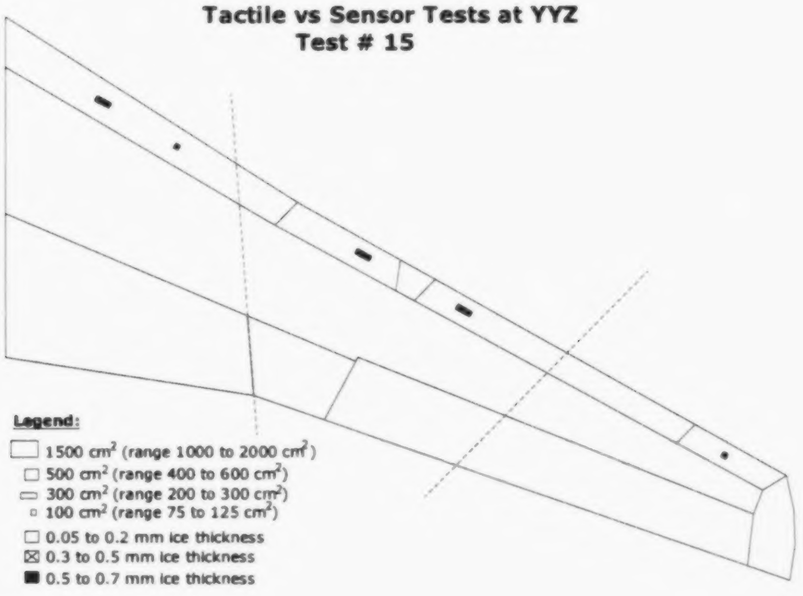
Tactile vs Sensor Tests at YYZ
Test # 13


Legend:
1500 cm^2 (range 1000 to 2000 cm^2)
500 cm^2 (range 400 to 600 cm^2)
300 cm^2 (range 200 to 300 cm^2)
100 cm^2 (range 75 to 125 cm^2)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness



Tactile vs Sensor Tests at YYZ
Test # 14

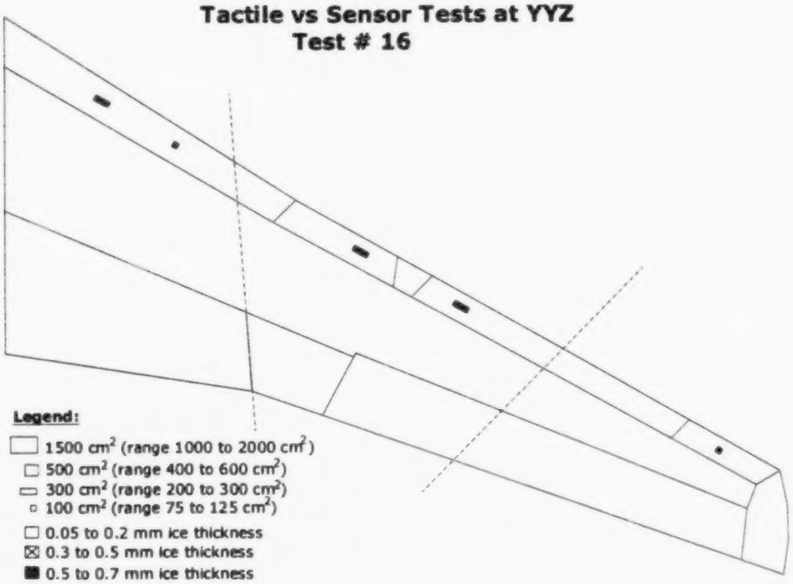
Legend:
1500 cm² (range 1000 to 2000 cm²)
500 cm² (range 400 to 600 cm²)
300 cm² (range 200 to 300 cm²)
100 cm² (range 75 to 125 cm²)
0.05 to 0.2 mm ice thickness
0.3 to 0.5 mm ice thickness
0.5 to 0.7 mm ice thickness



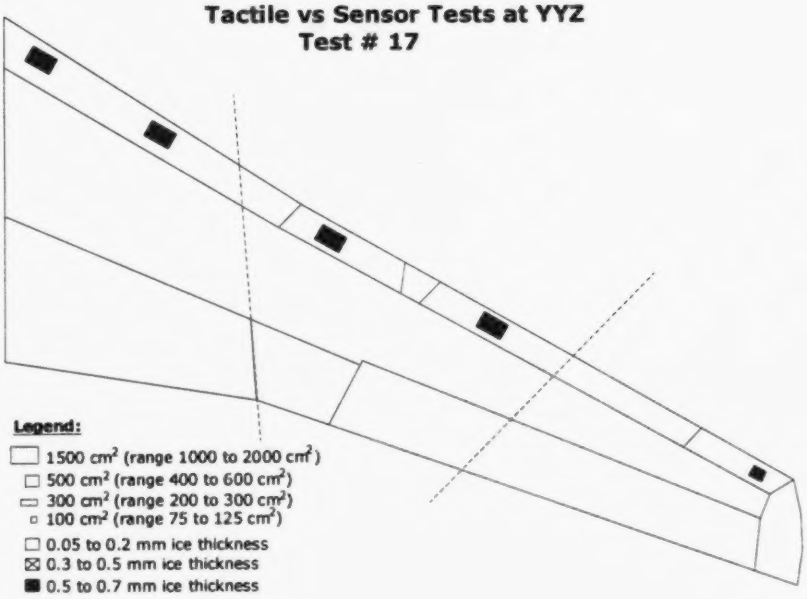
Tactile vs Sensor Tests at YYZ
Test # 15

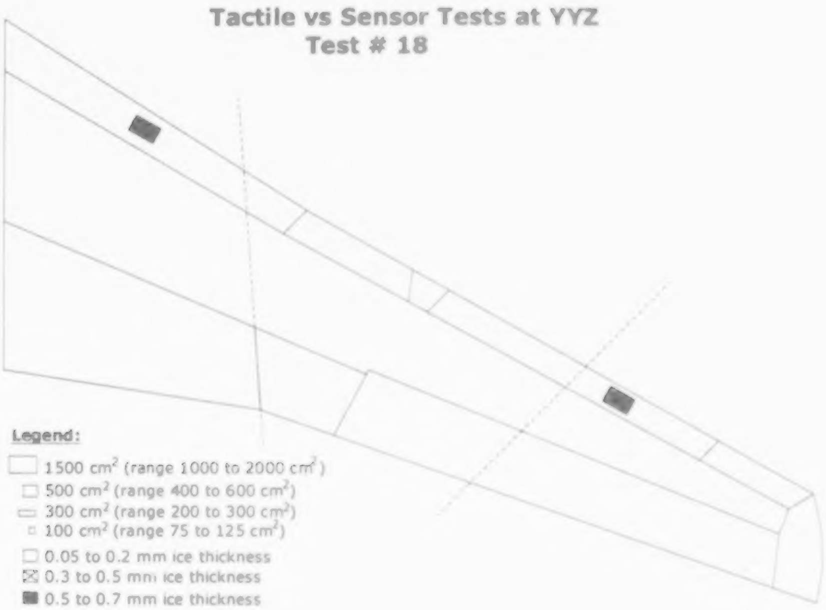
Legend:
1500 cm² (range 1000 to 2000 cm²)
500 cm² (range 400 to 600 cm²)
300 cm² (range 200 to 300 cm²)
100 cm² (range 75 to 125 cm²)
0.05 to 0.2 mm ice thickness
0.3 to 0.5 mm ice thickness
0.5 to 0.7 mm ice thickness

Tactile vs Sensor Tests at YYZ
Test # 16

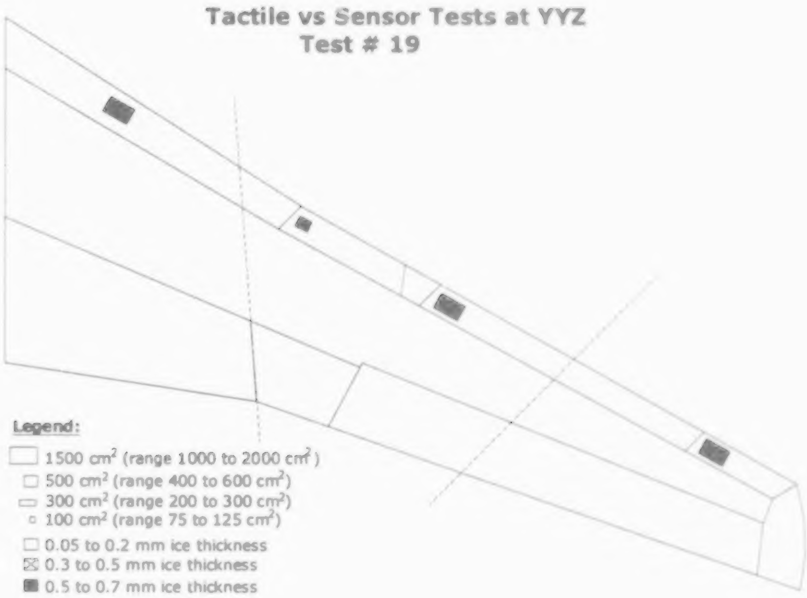

Legend:
▭ 1500 cm² (range 1000 to 2000 cm²)
☐ 500 cm² (range 400 to 600 cm²)
▭ 300 cm² (range 200 to 300 cm²)
▫ 100 cm² (range 75 to 125 cm²)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness

Tactile vs Sensor Tests at YYZ
Test # 17

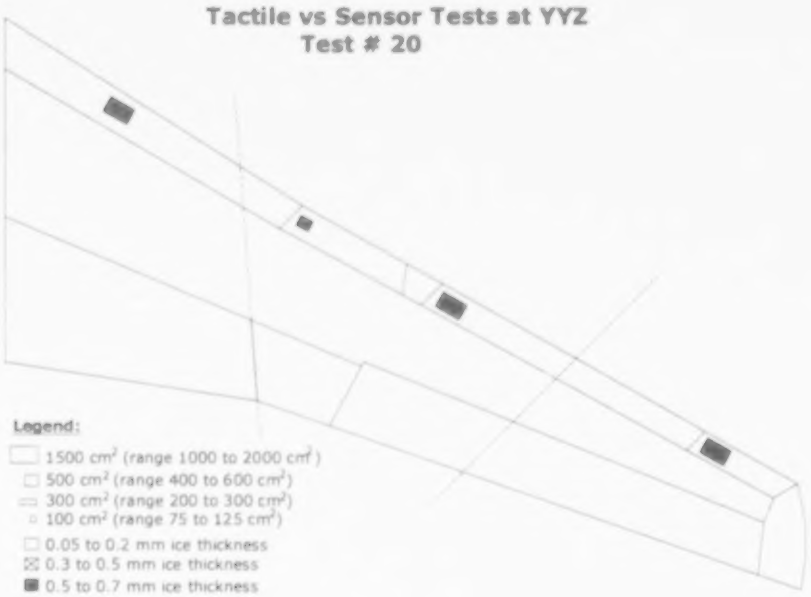

Legend:
▭ 1500 cm² (range 1000 to 2000 cm²)
☐ 500 cm² (range 400 to 600 cm²)
▭ 300 cm² (range 200 to 300 cm²)
▫ 100 cm² (range 75 to 125 cm²)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness


Tactile vs Sensor Tests at YYZ
Test # 18

Legend:
1500 cm^2 (range 1000 to 2000 cm^2)
500 cm^2 (range 400 to 600 cm^2)
300 cm^2 (range 200 to 300 cm^2)
100 cm^2 (range 75 to 125 cm^2)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness


Tactile vs Sensor Tests at YYZ
Test # 19

Legend:
1500 cm^2 (range 1000 to 2000 cm^2)
500 cm^2 (range 400 to 600 cm^2)
300 cm^2 (range 200 to 300 cm^2)
100 cm^2 (range 75 to 125 cm^2)
☐ 0.05 to 0.2 mm ice thickness
☒ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness


Tactile vs Sensor Tests at YYZ
Test # 20
Legend:
1500 cm² (range 1000 to 2000 cm²)
500 cm² (range 400 to 600 cm²)
300 cm² (range 200 to 300 cm²)
100 cm² (range 75 to 125 cm²)
☐ 0.05 to 0.2 mm ice thickness
▨ 0.3 to 0.5 mm ice thickness
■ 0.5 to 0.7 mm ice thickness

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APPENDIX D

EXPERIMENTAL PROGRAM
TYPE II / IV FLUID APPLIED INTO THE FORCED AIR STREAM

CM1680

TEST PROGRAM - FORCED AIR SYSTEMS

TYPE II / TYPE IV FLUID *APPLIED OVER* or *INJECTED INTO* THE FORCED AIR STREAM

Prepared for

SAE G-12
Equipment Subcommittee
Forced Air Working Group

Dawson

Prepared by: Peter Dawson

Reviewed by: John D'Avirro Kevin Cooper for

APS AVIATION INC. APS

Version 1.4
05 June 2002

1. OBJECTIVE

These tests are designed to examine whether published SAE holdover time guidelines can be approved for use when Type II / Type IV fluid is applied to aircraft surfaces with the assistance of forced air systems.

The nature of the assistance typically can take either of two forms:

a. The fluid nozzle can be positioned above the forced air nozzle, with the goal of carrying the fluid stream on top of the air stream.

b. The fluid nozzle can be positioned to inject fluid within the air stream, where the fluid is mixed with, and carried as part of the air stream.

This examination compares the quality of fluid application produced by the forced air assist application, with the quality of a standard application.

2. APPROVAL PROCESS

Each combination of forced air deicing truck configuration and SAE Type II / Type IV fluid requires individual approval. The following steps are involved in the approval process:

1. A standard procedure for testing and data gathering is developed and approved; by FAA, TC and the SAE G-12 Equipment Subcommittee Forced Air Working Group.
2. Prior to testing, in-house development of spray techniques and procedures is completed by the operator. The forced air systems planned for use in testing are to be verified by the manufacturer or operator's maintenance staff to confirm that they are operating within manufacturer specifications.
3. When the operator is satisfied that it has evolved a suitable application procedure, the operator schedules a test session, inviting observers from FAA Technical Center and Transport Canada (TDC).
4. Tests are conducted to gather required data. A set of five tests is required, to demonstrate repeatability. Tests are conducted on aircraft wings. Each test involves applying fluid with air assist on one wing, and applying fluid with the operator's standard Type II / Type IV nozzle and procedure on the other wing, as a benchmark.
5. If deemed satisfactory by the operator, test results are submitted to the following FAA/TC addressees to be considered for approval to use Type II / Type IV published HOT guidelines, for that specific truck / Type II / Type IV fluid combination.

Charles O. Masters Manager, Flight Safety Research FAA Technical Centre Building 210 AAR 421 Atlantic City International Airport Atlantic City, NJ 08405 mastersc@tc.faa.gov	Barry Myers Senior Development Officer Transport Canada Transportation Development Centre 800 René-Lévesque Blvd. West, 6th Floor Montréal, Québec H3B 1X9 myersbb@tc.gc.ca

6. The approval decision rests on whether the forced air assist process produces results that are equivalent to the standard fluid application process. The factors considered are:
   - Fluid viscosity as measured from samples lifted from the wing
   - Fluid thickness measured at various points on the wing
   - Consistency of distribution of the fluid layer over the sprayed area on the wing.

3. TEST PROCEDURE

3.1 General

These tests are designed to be conducted in the field by the equipment operator. Equipment and fluid manufacturers will be invited to test sessions. Fluid samples are to be tested under laboratory conditions.

3.2 Test Planning

3.2.1 Weather Conditions

These tests are performed in dry conditions.

Some of the set of five required tests may be performed in non-winter conditions, with wing skin temperature not warmer than 15°C. At least one test is to be performed in freezing conditions as confirmation that warm OAT does not affect test results related to fluid viscosity.

At least one test is performed in *into-wind* conditions.

3.2.2 Test Surface

Tests are to be conducted on dry wings of out-of-service aircraft (example, parked overnight).

Care must be taken to ensure that there is no residue of Type I fluid on the wings, as this will result in some mixing of Type I within the Type II / Type IV fluid, and will produce inaccurate viscosity measurements.

To avoid the risk of presence of Type I fluid, removal of Type II / Type IV fluid between consecutive tests can be performed by use of heated water or heated Type I fluid, followed by an application of forced air to dry the wing. Ensure that the wing temperature has cooled to ambient before conducting subsequent tests.

If the tests are conducted in freezing temperatures, the final cleaning of Type II / Type IV fluid following the last test is to be performed with heated Type I fluid, prior to returning the aircraft to service.

3.2.3 Test Fluid

The fluid used for test purposes is qualified standard production fluid.

3.2.4 Configuration of Forced Air System

The normal operating configuration of the forced air systems is to be used for testing. If the air-flow is operator controlled, the test is to be conducted at maximum air flow.

The operating performance of forced air systems planned for use in these tests is to be checked prior to tests. This may be done by the manufacturer or by the operator's technical staff in accordance with manufacturer's guidelines. Certification that systems are operating within manufacturers specifications is required for each truck used in testing. A completed and signed **DECLARATION OF CONFORMITY** (Attachment D-Ia) is to be submitted for each forced air deicing vehicle used in the tests. A sample completed form (Attachment D-Ib) is included for guidance.

3.2.5 Test Matrix

Five tests are to be conducted, to examine repeatability. If the main series of tests is conducted in warm weather, test number 5 in the test matrix must be conducted below freezing condition.

Table D-1: Test Matrix

Test Number	Type of Application	Special Test Condition
1a	Air-assist	Alternate air-assist test between port and starboard wings to eliminate any effect of wind-direction
1b	Standard	
2a	Air-assist	
2b	Standard	
3a	Air-assist	Duplicate of test 1 or 2
3b	Standard	
4a	Air-assist	Spray into-wind (conduct consecutive tests on the same wing to ensure the same wind affect)
4b	Standard	
5a	Air-assist	Cold OAT (below 0°C)
5b	Standard	

3.2.6 Test Equipment

A list of equipment needed to conduct the tests is provided in Attachment D-II.

3.3 Data Forms

Two data forms are used for these tests as follows.

3.3.1 General Form (Figure D-1)

This is a cover form for all tests completed during a single test session. An operator signature verifies that deicing trucks used for tests have been checked to confirm that they operate in accordance with manufacturer's specifications. The specifications for the forced air system may be provided by completing the form, or by attaching a copy of the manufacturer's equipment description.

This form is completed only once per test session.

3.3.2 Test Data Form (Figure D-2)

This form is completed for each wing tested. Each test consists of an application of fluid on one wing using air-assist, and on the other wing using the operators standard Type II / Type IV fluid nozzle and procedure; thus two forms are completed for each test.

The form is designed to record data specific to fluid applied at minimum and maximum distances.

Values for OAT and wind speed can be retrieved from the local Met office.

3.4 Conducting the Tests

3.4.1 Fluid Application

To enable measurement of minimum and maximum distance of effective spray, the operator should be positioned at a fixed location relative to the test wing. Fluid is then applied over the wing (span-wise and chord-wise) from the fixed position, with the objective of determining the reach limitations.

Record the start and finish times for spray. If the truck is equipped, record the quantity of fluid sprayed.

The minimum and maximum distances from nozzle are measured, and the angle of the fluid stream to the horizontal is estimated.

For the test of spray *into-wind*, the operator should be positioned accordingly. This may require spraying from the rear of the wing.

3.4.2 Measuring Fluid Thickness

Allow at least 3 minutes for the fluid to settle, and measure fluid thickness on the wing at the locations where minimum distance and maximum distance was observed. The boundary of the area where satisfactory coverage was achieved may take the shape of an arc across the wing. In that case, the measurements should be taken within that arc, at the chord locations indicated.

Refer to Attachment D-III for equipment and procedures.

3.4.3 Noting Appearance of Fluid Layer

Grade the appearance as noted on the data form. This may be somewhat subjective, however the intent is simply to allow comparison between the air-assist and standard methods of application, so the important thing is consistency in grading. For continuity in each test, the same person should report the fluid appearance on both wings (the wing treated with the forced air assist, and the other wing treated with a standard application).

3.4.4 Taking Fluid Samples for Aeration and Viscosity Test

Sample containers as described by the appropriate fluid manufacturer for submission of fluid samples are suitable for this test. In preparation for measuring fluid aeration, first label each bottle and cap. The empty bottle with its cap is then weighed and the weight recorded. The volume capacity of each bottle when filled to overflowing and then capped, is measured and recorded. Maintain a list of container labels along with measured weight (empty and capped), and volume capacity.

An initial sample is required from the truck tank, to serve as a reference base. This sample may be taken directly from the tank by dipping from the top, or from the bottom drain valve. If taken from the drain valve, allow enough fluid to drain to completely flush the line before taking the sample.

Two samples are lifted from the wing surface for each test; one at minimum and one at maximum distance. At least 120 mL (4 oz.) is required for each sample. Fluid will need to be gathered from a fairly large area (in the order of 0.4 m^2 or 4 sq. ft.) to accumulate this amount, so this activity should take place after recording of other test data (thickness and appearance).

To gather samples from the wing surface, it is recommended that the fluid be pulled together on the wing surface using flexible plastic sheets as scrapers. Then flow the accumulated fluid onto one plastic sheet, and, by bending the plastic sheet, pour the lifted fluid into the sample bottle. Plastic dustpans are also suitable for fluid collection. Two people are needed for this activity. Alternatively, if the wing structure allows it, the fluid can be flowed to the edge of the wing, and captured as it flows off.

As each bottle is filled, ensure that a record is maintained clearly linking the sample bottle label to test number, maximum or minimum position and date/time of test.

Samples are to be sent to a qualified lab within 24 hrs, for prompt testing.

To measure fluid aeration, first weigh the filled bottles without removing with their caps. Calculate the fluid density based on the recorded empty bottle weight and volume capacity. Calculate the percentage change to fluid density due to aeration by comparison to the density of the virgin sample taken from the truck tank as a base of reference.

Fluid viscosity is to be measured in accordance with the fluid manufacturer's procedure. Fluid samples are to be centrifuged before testing for viscosity.

Test results received back from the fluid manufacturer are to be entered on the test data form, prior to submitting the completed test data forms for approval to use holdover times.

3.4.5 Preparing for Next Test

To prepare for the next test, remove all Type II / Type IV fluid from the wing. This can be done with heated water or heated Type I fluid, and then dried using forced air.

Attachment D-la

Declaration of Conformity

Manufacturer or Operator Maintenance Department:

____
____
____
____

Notify that the machine hereunder mentioned:

Equipment: ____________________
Type: ____________________
Serial Number: ____________________

Complies with the Manufacturers Specifications.

Date: ________________________

Signature: ________________________

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Attachment D-Ib

Sample of a Completed Declaration of Conformity

Manufacturer or Operator Maintenance Department:

Global Ground Support
540 East US Hwy 56
Olathe, KS 66061

Notify that the machine hereunder mentioned:

Equipment: Aircraft Deicer
Type: 2100 LFTE
Serial Number: TE21-1099-0020

Complies with the Manufacturers Specifications.

Date: ____________________

Signature: ____________________

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Attachment D-II

Test Equipment Checklist
Trials for Type II / Type IV Fluid Applied over or Injected into the Forced Air Stream

TASK	*STATUS*
Logistics For Every Test Session	
Schedule test with truck and fluid manufacturers	
Advise FAA, TDC	
Arrange for test aircraft	
Test Equipment	
Forced air deicing truck	
Test procedures	
Data Forms	
Clipboards	
Pencils	
Wiper rags	
Fluid thickness gauges	
Fluid sample containers with labels (24)	
Plastic to pick up fluid samples from wing	
Lighting for stands	
Access stands for observers at wing	
Flashlights	

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Attachment D-III

Measuring Fluid Film Thickness

Fluid thickness can be measured with use of a wet film thickness gauge. Two types are recommended as follows.

The Octagon wet film thickness gage ranges from 0.4 to 400 mils. It is available with a micron scale on the reverse side. This gauge is suitable for normal on-wing thickness for Type II / Type IV fluid. Part number WF-OCT.

The second gauge is a standard stock gage ranging from 1 to 80 mil. This gauge gives better accuracy for thinner films, such as seen with Type I fluid on wings, or thinner applications of Type II / Type IV fluid. Part number WF-CCA.

Both gauges are available from:

Paul N. Gardner Company, Inc.
316 NE 1st St. POMPANO BEACH, Fl 33060
1-800-762-2478 (954) 946-9454 FAX (954) 946-9309

Instructions for Use

1. Place the gauge in the fluid at 90° to the underlying surface, selecting the gauge side that allows a tooth to touch the fluid surface.
2. Note the last tooth that is wetted. This can be done by withdrawing the gauge and observing which is the last tooth wetted, or by peering under the gauge while inserted in the fluid, noting which is the last tooth touching the fluid surface. With clear fluid, the latter method usually works better.
3. Record the value of the last tooth wetted.
4. Dry the gauge before next use.
5. If repeat measurements are taken, ensure that the gauge is slightly offset from the previously measured location as the fluid surface may still be indented from the earlier measure.

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Figure D-1: SAE G-12 EQUIPMENT SUBCOMMITTEE
TYPE II / TYPE IV FLUID WITH AIR ASSIST - GENERAL FORM

(Complete One Per Test Session For Each Truck / Fluid Combination)

OPERATOR____________ LOCATION____________ DATE____________

AIRCRAFT TYPE ____________

FLUID MANUFACTURER AND TYPE ____________

TRUCK MANUFACTURER AND TYPE ____________

TRUCK SERIAL NUMBER (S) ____________ ____________ ____________

(Operator verifies that deicing trucks used for these tests have been checked to confirm operation in accordance with manufacturer's specifications. System specifications can be provided by completion of the following or by submission of the manufacturer's system description.)

OPERATOR REPRESENTATIVE NAME (BLOCK LETTERS), SIGNATURE AND TELEPHONE

____________ ____________ ____________

APPLICATION OF TYPE II / IV WITH AIR
- SYSTEM DESCRIPTION

INJECTED INTO AIR STREAM ____________

OR OVER AIR STREAM

FLUID FLOW RATE ____________

FLUID NOZZLE TYPE ____________

FLUID PRESSURE ____________

AIR PRESSURE ____________

AIR FLOW RATE ____________

TYPE II / IV STANDARD APPLICATION
- SYSTEM DESCRIPTION

FLUID NOZZLE TYPE ____________

FLUID PRESSURE ____________

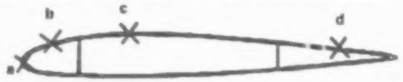
FLUID FLOW RATE ____________

Figure D-2: SAE G-12 EQUIPMENT SUBCOMMITTEE TYPE II / TYPE IV FLUID WITH AIR ASSIST - DATA FORM

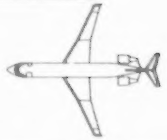
(Complete One Form for Each Wing Tested)

OPERATOR ________ LOCATION ____________________ DATE ________ TIME ______ RUN # _____
TRUCK MANUFACTURER AND TYPE ____________ TRUCK NUMBER ______________________________
OAT ______ WIND SPEED __________ FLUID MANUFACTURER AND TYPE _______________
TYPE OF APPLICATION Over Air Stream ___ Injected In Air Stream ____ Standard Application __________
SPRAY PATTERN SETTING ___ % Fan; Solid Stream ______; Other ____________________________
SPRAY START TIME ________ SPRAY END TIME ________ FLUID QUANTITY APPLIED ______________

LOCATION FOR FLUID THICKNESS MEASUREMENT



- CIRCLE WING SPRAYED
- PENCIL IN WIND DIRECTION RELATIVE TO WING TESTED



AT MINIMUM EFFECTIVE DISTANCE

Minimum distance from nozzle ____ ft
Estimated angle of stream to horizontal ____ °
Fluid thickness on wing chord at Min distance
a _______ mil b ______ mil
c _______ mil d ______ mil

Appearance of Fluid Layer at Min distance
(grade each line from 1 to 5)
1 5
VERY RIDGED ____________ *CONSISTENT THICKNESS*
Patchy colour ____________ Consistent colour
Highly aerated ____________ Few bubbles
Surface appears as if contaminated
Yes ____________ No
Other comments:

Label on Fluid Sample _____ **Aeration** ____ %
Sample Viscosity _______ **Brix** ________
Recorded by:

AT MAXIMUM EFFECTIVE DISTANCE

Maximum distance from nozzle ____ ft
Estimated angle of stream to horizontal ____ °
Fluid thickness on wing chord at Max distance
a _______ mil b ______ mil
c _______ mil d ______ mil

Appearance of Fluid Layer at Max distance
(grade each line from 1 to 5)
1 5
Very ridged ____________ Consistent thickness
Patchy colour ____________ Consistent colour
Highly aerated ____________ Few bubbles
Surface appears as if contaminated
Yes ____________ No
Other comments:

Label on Fluid Sample _____ **Aeration** ____ %
Sample Viscosity _______ **Brix** ________
Recorded by: ______________________

APPENDIX E

EXPERIMENTAL PROGRAM
TYPE I FLUID APPLIED OVER OR INJECTED INTO THE FORCED AIR STREAM

TEST PROGRAM - FORCED AIR DEICING SYSTEMS TYPE I FLUID *APPLIED OVER* or *INJECTED INTO* THE FORCED AIR STREAM

1. OBJECTIVE

These tests are designed to assist operators in examining whether air-assisted Type I fluid can be used as the first-step of a two-step process to clean aircraft surfaces, when followed with an application of Type IV anti-icing fluid. The critical factors for consideration are:

- Does the procedure produce a clean surface?
- Does the surface remain uncontaminated long enough to allow the over-spray of Type IV fluid?
- Does the force of the airstream push slush into wing cavities?

The nature of the air-assistance can take either of two forms:

- The fluid nozzle can be positioned above the forced air nozzle, with the goal of carrying the fluid on top of the airstream.
- The fluid nozzle can be positioned to inject fluid within the airstream, where the fluid is mixed with, and carried as part of the airstream.

This test examines the condition of the wing surface following deicing, and measures the elapsed time until refreezing begins to occur. The nature of contamination is assumed to be snow throughout this procedure.

2. TEST PROCESS FOR ELAPSED TIME TO FIRST FREEZING

2.1 Background

In a two-step deicing operation, it is a safety requirement that the wing surfaces (or other critical surfaces) remain free of contamination when the second step anti-icing fluid is applied. SAE ARP4737 gives a *3-minute* guideline as the time that the surface might be expected to remain uncontaminated. However this is only a guideline, and the deicing operator is always responsible for ensuring that the surfaces are still uncontaminated when the anti-icing fluid is applied.

The two factors controlling the time to refreeze on a wing are:

- The freeze point of the fluid on the wing, and
- The wing surface temperature.

The interplay of these two factors is shown in the chart in Attachment E-I. Freezing will occur when the fluid freeze point matches the wing temperature. If the wing has been heated above OAT, then the intersection of the two curves will occur later than if the wing had not been heated, or had been heated to a lesser degree.

As the fluid progressively dilutes, the fluid freeze point rises. The rate of dilution for the typical thin film of Type I fluid on a wing is very rapid; in the conditions reported on the chart, the fluid freeze point matched OAT within two minutes. If the wing had not been heated at all, this is where first freezing would have occurred. The factors influencing the rate of progression of the fluid freeze point include:

- The initial freeze point of the fluid

- The initial thickness of the fluid layer on the wing

- The rate of snowfall

- The local geometry of the wing surface (affects rate of run-off and fluid feed from other areas).

The factors influencing the wing surface temperature include:

- Initial wing temperature
- Fluid temperature
- Quantity of fluid applied
- Operator technique
- Outside air temperature (OAT)
- Wind
- Cooling from precipitation
- Fuel quantity and temperature.

A universal test to establish elapsed time to first freezing would need to address all of these factors at their most severe conditions (high wind, heavy snowfall, cold OAT, etc). As this is uncontrollable in field testing, and is probably unrealistic for the application, a different approach to determining test conditions is needed.

A second consideration in designing the test is the criteria for success. Two alternatives could be:

- Producing an elapsed time to first freezing equivalent to a standard spray of heated fluid

- Producing an elapsed time to first freezing long enough to allow an application of Type IV fluid. The *3-minute* guideline could be the benchmark for this approach.

The approach where the results from the air-assisted spray are compared to a standard spray may not be satisfactory. Depending on test conditions, the standard spray could produce an elapsed time to first freezing much longer than the air-assist spray, and yet the elapsed time from the air-assist might be sufficient (in the order of 3-minutes).

2.2 Operator Approval Process

From the preceding, it can be seen that results of tests conducted in mild conditions could not be applied to more severe conditions.

Because the field test conditions are uncontrollable, it is suggested that a base of test experience be built up among the various interested operators. The results of these trials could be pooled, and when it is believed that sufficient information has been gathered for a range of conditions, then an operator decision can be made regarding introducing air-assisted first-step deicing into an operation.

If an operator decides to introduce air-assisted Type I fluid as a first-step procedure, then the following would be required in the Operator Procedures and Training:

- Acceptable weather limits (based on test experience) would be identified
- Emphasis would be placed on deicing operator responsibility for ensuring that the deiced surfaces are still uncontaminated when the anti-icing fluid is applied. If the surface refreezes before Type IV fluid can be applied, then the wing would need to be re-deiced using the standard heated fluid spray.

Each forced air deicing truck configuration would require separate investigation. The following steps are suggested:

1. Prior to testing, in-house development of spray techniques and procedures is completed by the operator.
2. When the operator is satisfied that it has evolved a suitable application procedure, the operator schedules a test session, inviting observers.
3. Tests are conducted to gather required data. A set of five tests is suggested, to demonstrate repeatability. Tests are conducted on aircraft wings. Base case tests applying fluid with the operator's standard Type I nozzle and procedure are suggested as a benchmark.
4. Test results are then submitted to other interested operators and to the SAE Forced Air Working Group for pooling with test results from other operators using the same systems, and for discussion. Test results for different manufacturer systems should be treated separately.
5. An operators decision to use an air-assisted Type I fluid application as the first step of a two-step deicing procedure, would then be based on test results for a specific truck type:
   - Ability of the procedure to provide a clean wing
   - Elapsed time following deicing until freezing first appears.

3. TEST PROCEDURE

3.1 General

These tests are designed to be conducted in the field by the equipment operator together with the equipment manufacturer.

It is expected that the test session to produce data to support a decision would be performed only after the equipment user and manufacturer have developed procedures that produce a consistently satisfactory fluid application.

A list of test equipment, specific to tests for air-assisted Type I fluid, is included in Attachment E-II.

3.2 Test Planning

3.2.1 Weather Conditions

These tests are performed during snowfall, with OAT below freezing (suggest -3°C or colder). More than one test session is recommended to provide results for different ambient conditions.

Perform at least one test in *into-wind* conditions.

3.2.2 Test Surface

Conduct tests on out-of-service aircraft (example, parked overnight). The aircraft should be parked nose-into-the-wind for the tests.

Following the last test, the aircraft is to be deiced with a standard application of heated Type I fluid, prior to returning the aircraft to service.

3.2.3 Test Fluid

The fluid used for test is qualified standard production SAE Type I fluid mixed to a buffer of 10°C (18°F).

3.2.4 Configuration of Forced Air system

The normal operating configuration of the forced air deicing system is to be used for testing, and details are to be recorded on the data forms.

If the air-flow is operator controlled, the test is to be conducted at maximum air flow.

3.2.5 Test Matrix

Five tests are suggested, to demonstrate repeatability. It is suggested that more than one test session be conducted to provide results for varied conditions (snow rates, OAT, wind). Tests on standard fluid and air-assisted fluid should be alternated between wings to eliminate any effect of variability of wind and snowfall. An examination of wing cavities for presence of slush is scheduled for one set of tests.

Each test consists of an application of fluid on one wing using air-assist, and on the other wing using the operator's standard Type I fluid nozzle and procedure.

Test Number	Weather Condition	Type of Application	Special Test Condition
1a	Snow	Air-assist	Alternate air-assist / standard tests between wings to eliminate any effect of variation in wind or snowfall. Examine cavities for slush on one test.
1b		Standard	
2a		Air-assist	
2b		Standard	
3a	Snow	Air-assist	Alternate air-assist / standard tests between wings to eliminate any effect of variation in wind or snowfall.
3b		Standard	
4a		Air-assist	
4b		Standard	
5a	Snow	Air-assist	Spray into-wind
5b		Standard	

3.3 Data Forms

Three data forms are used for these tests as follows.

3.3.1 General Form (Figure E-1)

Complete the general form, ensuring that all pertinent data describing the forced air deicing system configuration is recorded. This form is completed only once per test session.

3.3.2 Spray Form (Figure E-2)

This form is completed for each wing tested, and is used to record data specific to test conditions, and to the fluid used to deice the wing. As each test consists of an application of fluid on one wing using air-assist, and on the other wing using the operator's standard Type I fluid nozzle and procedure, two forms are completed for each test.

Values for OAT, wind speed and snow rate can be retrieved from the local Met office.

3.3.3 Wing Form (Figure E-3)

This form is used to record the occurrence of earliest freezing on the wing following deicing, and the extent of refreezing at five minutes following deicing. A diagram of a generic wing is used to indicate where freezing occurred.

Condition of wing cavities (presence of slush) is also recorded on this form.

3.4 Conducting Tests for Elapsed Time to First Freezing

3.4.1 Synchronizing Time Pieces

As this test examines the elapsed time from deicing to first freezing, it is very important that observers' timepieces be synchronized at the start of the test session.

3.4.2 Wing Condition at Start of Tests

Allow a covering of snow to accumulate on the wings prior to each test (0.6 cm to 1.3 cm or 0.25 to 0.5 in. is suggested). Record depth of snow on the wing by measuring at several locations and averaging the results.

3.4.3 Measuring Fluid Temperature and Brix

Use Data Form (Figure E-2) to record the fluid temperature at the nozzle prior to spraying the wing. This will serve to clear the line of cold fluid. For the standard spray, this can be done by spraying into a bucket or other open container positioned close to the nozzle, and measuring the temperature of the fluid in the container until it stabilizes. For the air-assist fluid, it may be necessary to insert a hand-held temperature probe into the fluid stream at the nozzle. Tank fluid temperature is also measured. Record the Brix value of the test fluid.

3.4.4 Cleaning the Wing

Deice the entire wing according to the operator's procedure. Accurately record (Data Form Figure E-2) the start and finish times for spray. Record the quantity of fluid sprayed. Note the direction of wind and the operator's position, on the wing sketch.

For the test requiring deicing by spraying *into-wind*, the operator must position the truck accordingly. This may require spraying from the rear of the wing.

When the operator completes deicing the wing, examine the wing surface. Note and record whether the wing is completely cleaned, or the extent and location of any remaining contamination.

3.4.5 Recording the Time of First Freezing

Following completion of spraying, observe the wing for first indication of refreezing. As this may occur very quickly, access stands must be moved immediately to the wing to allow observers a good view of the wing surface. More than one observer is needed for this activity. For a large wing, four observer positions may be needed. Typically, first failure will occur either on the leading edge or rear control surfaces. The outer end of the wing is also more susceptible to early freezing.

Using Data Form Figure E-3, record the location and time that first freezing occurred, on the wing diagram.

Continue to observe the wing until 5 minutes following deicing. At that time, note the time, and sketch the area of any freezing on the wing.

3.4.6 Assessing Flying Debris

During the forced air application, observe the way the snow is removed from the wing. Record whether snow came off in chunks, and if so, how large they were and how far they were blown. Indicate whether the clumps might have been ingested in a rear-mounted engine.

3.4.7 Preparing for Next Test

Following each test, allow a covering of snow to accumulate on the wings prior to the next test (0.6 cm to 1.3 cm is suggested).

3.5 Conducting Tests for Condition of Wing Cavities

There is a potential concern that the airstream might force wetted-snow slush into wing cavities. To examine this possibility, cavities at flight control surfaces need to be examined. It is suggested that this be done on two occasions.

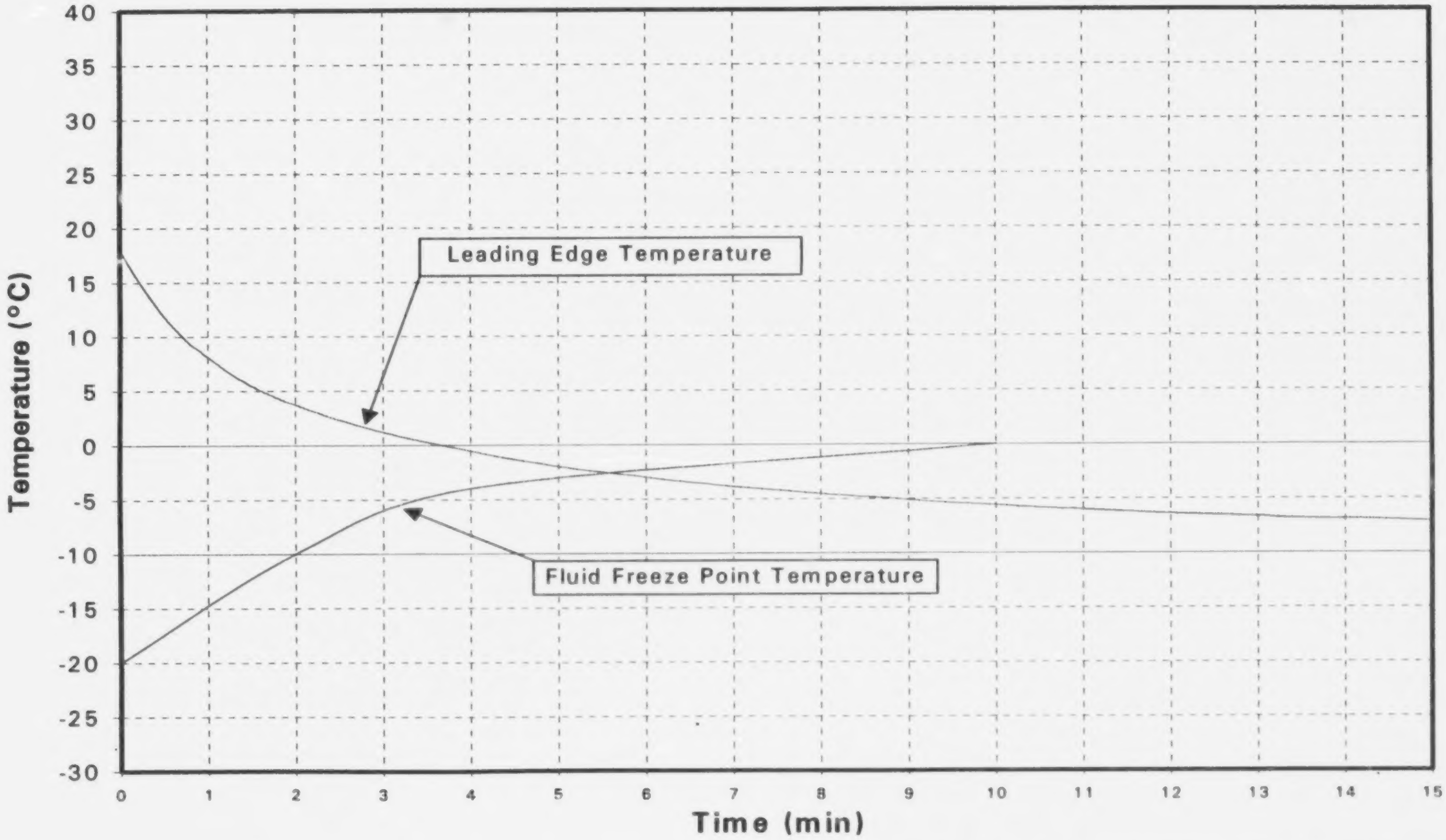
This test involves operating the leading edge slats and other control surfaces to enable observation of the cavities. Planning of personnel to operate the aircraft systems and associated aircraft power will be required.

This examination is conducted twice:

- before the spray test to ensure that the cavities are clean to start with, and
- following the final recording of wing condition at five minutes after deicing.

Operate the control surfaces to expose the underlying cavities. Note and record on the wing diagram the presence of any contamination, and its location, extent and nature.

Attachment E-I
Intersection of Wing Temperature and FFP Profiles
Heated Type I Fluid Application at OAT -10°C
Typical dilution curve, Snow @ 25 g/dm²/h, FFP @ 10°C Buffer



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ATTACHMENT E-II

TEST EQUIPMENT CHECKLIST TRIALS FOR AIR-ASSISTED TYPE I FLUID AS FIRST-STEP OF A TWO-STEP PROCEDURE

TASK	*STATUS*
Logistics For Every Test Session	
Schedule test with truck and fluid manufacturers	
Advise FAA, TDC	
Arrange for test aircraft	
Arrange for personnel and power to operate aircraft control surfaces	
Test Equipment	
Forced air deicing truck	
Test procedures	
Data Forms	
Clipboards	
Pencils	
Wiping rags	
Rule for snow thickness	
Brixometer	
Watches	
Fluid thermometer	
Fluid temperature probe	
Access stands for observers at wing	
Flashlights	

Figure E-1

SAE G-12 EQUIPMENT SUBCOMMITTEE
TYPE I FLUID WITH AIR ASSIST - GENERAL FORM

(Complete One Per Test Session)

OPERATOR ______________ LOCATION ______________ DATE ______________

NAME AND CONTACT OF OPERATOR REPRESENTATIVE ______________

TRUCK MANUFACTURER AND TYPE ______________

FLUID MANUFACTURER AND TYPE ______________

FLUID FREEZE POINT ______________

____

APPLICATION OF TYPE I WITH AIR - SYSTEM DESCRIPTION

INJECTED INTO AIR STREAM ___

OR OVER AIR STREAM ___

FLUID FLOW RATE ______________

FLUID NOZZLE TYPE ______________

FLUID PRESSURE ______________

AIR PRESSURE ______________

AIR FLOW RATE ______________

TYPE I STANDARD APPLICATION- - SYSTEM DESCRIPTION

FLUID NOZZLE TYPE ______________

FLUID PRESSURE ______________

FLUID FLOW RATE ______________

Operator Representative Signature ______________

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FIGURE E-2
SAE G-12 EQUIPMENT SUBCOMMITTEE
TYPE I FLUID - SPRAY FORM (EVERY TEST)

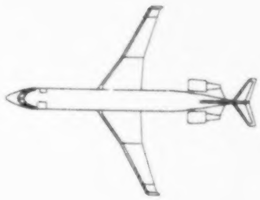
Date: ____________

Aircraft Type:

Run #: ____________

DRAW DIRECTION OF SPRAY AND WIND WRT WING:

Type of Application
☐ FLUID OVER AIR
☐ AIR/INJECTED FLUID
☐ FLUID



Truck #: ____________

TEST CONDITIONS

Type of Precipitation: ____________
Rate: Light Moderate Heavy
Depth of Snow on Wing ____________ in
OAT ____________ °F/°C
Wind: ____________ mph

DEICING APPLICATION

Start Time: ____________ hh:mm:ss
End Time: ____________ hh:mm:ss
Amount of Fluid Sprayed: ____________ gal / L
Type of Fluid: ____________
Fluid Temperature: Tank: ______ °F / °C
Nozzle: ______ °F / °C
Fluid Freeze Point: ____________

PROJECTILES DURING DEICING

Did snow removal throw clumps from the wing?: ____________
If clumps were blown from wing, what size: ____________
Distance clumps blown from wing: ____________
Did clumps pose danger of ingestion for rear mounted engines?: ____________

CONDITION OF WING AT END OF DEICING: ____________

MEASUREMENTS BY: ____________

HANDWRITTEN BY:

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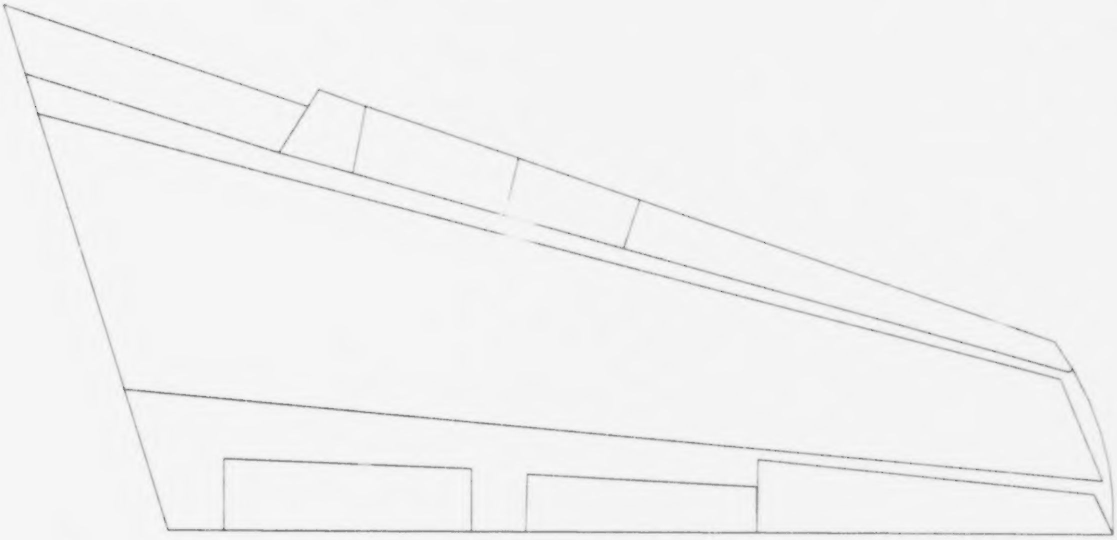
FIGURE E-3

SAE G-12 EQUIPMENT SUBCOMMITTEE
TYPE I FLUID - WING FORM (EVERY TEST)

DATE: ____________________ **RUN #:** __________

RECORDING INFORMATION:

- At time of 1st	- Note location and time on wing
- 5 minutes after	- Record patterns of ice on the wing
- Wing Cavity	- Record appearance of any ice formation. Use additional forms as



COMMENTS: ____

____

____

ICING RECORD BY: ____________________

HANDWRITTEN BY: ____________________

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APPENDIX F

DEMONSTRATION OF THE PROCEDURAL REQUIREMENTS SPECIFIED IN GMOPS AS 5116A TO CONDUCT ICE DETECTION TRIALS
AND
REVISION OF GMOPS AS 5116A

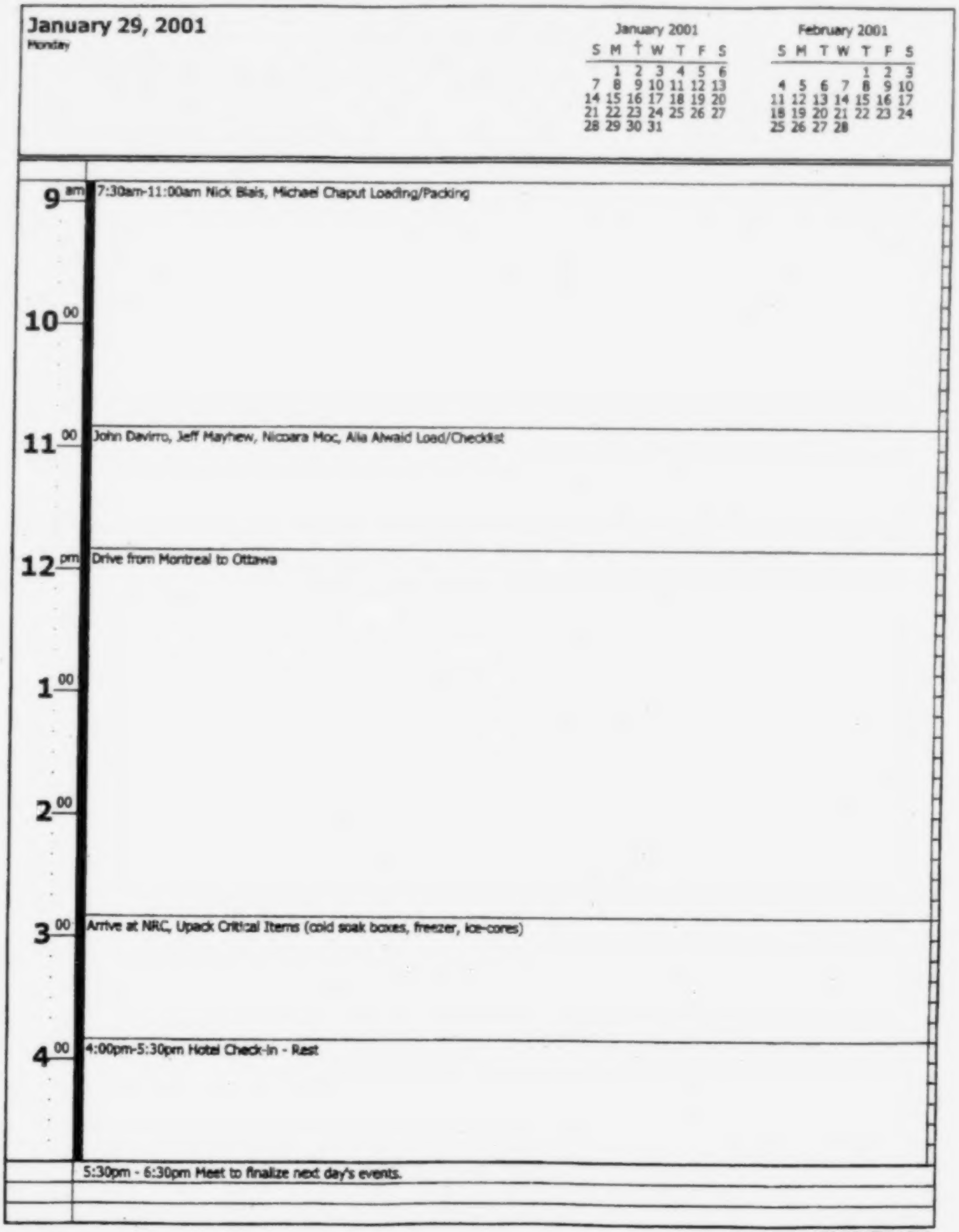
This appendix contains the following two documents:

- Demonstration of the Procedural Requirements specified in GMOPS as 5116 A to Conduct Ice Detection Trials

This document contains a brief description of the events that took place during the two-day demonstration at the National Research Council in January 2001 for the EUROCAE Working Group 54 and the Society of Automotive Engineers (SAE) G-12 Ice Detection Subcommittee. The purpose of these trials was to introduce the members of the subcommittee to the procedures required to conduct laboratory trials for evaluating the minimum operational performance requirements of ice detection sensors.

- Revision of GMOPS AS 5116A

This document contains a list of the changes that have been proposed during the SAE G-12 Ice Detection Subcommittee meeting, pertaining to issues raised by APS and the reasoning behind these changes. These itemized modifications reflect the recommendations and approval of the members of the subcommittee that were present at the meeting.



January 29, 2001

Monday

January 2001

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February 2001

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

9 am 7:30am-11:00am Nick Blais, Michael Chaput Loading/Packing

10 00

11 00 John Davirro, Jeff Mayhew, Nicoara Moc, Alia Alwaid Load/Checklist

12 pm Drive from Montreal to Ottawa

1 00

2 00

3 00 Arrive at NRC, Upack Critical Items (cold soak boxes, freezer, ice-cores)

4 00 4:00pm-5:30pm Hotel Check-In - Rest

5:30pm - 6:30pm Meet to finalize next day's events.

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January 30, 2001
Tuesday

January 2001

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February 2001

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

9 am	INTRODUCTION IN U89	Briefing on Day Routine
		Introduction to NRC Facility
	TOUR OF FACILITY U88	
10 00	DEMO IN U88	Ice Disc Demo
		Frost Demo
11 00		Rate Demo
		Fluid Failure Demo LZR
12 pm		
	LUNCH U89	
1 00		
	DEMO IN U88	Fluid Failure Snow NCAR
2 00		
		Fluid Failure Demo ZL
3 00		Fog Visibility Demo
4 00		
	Wrap Up U89	

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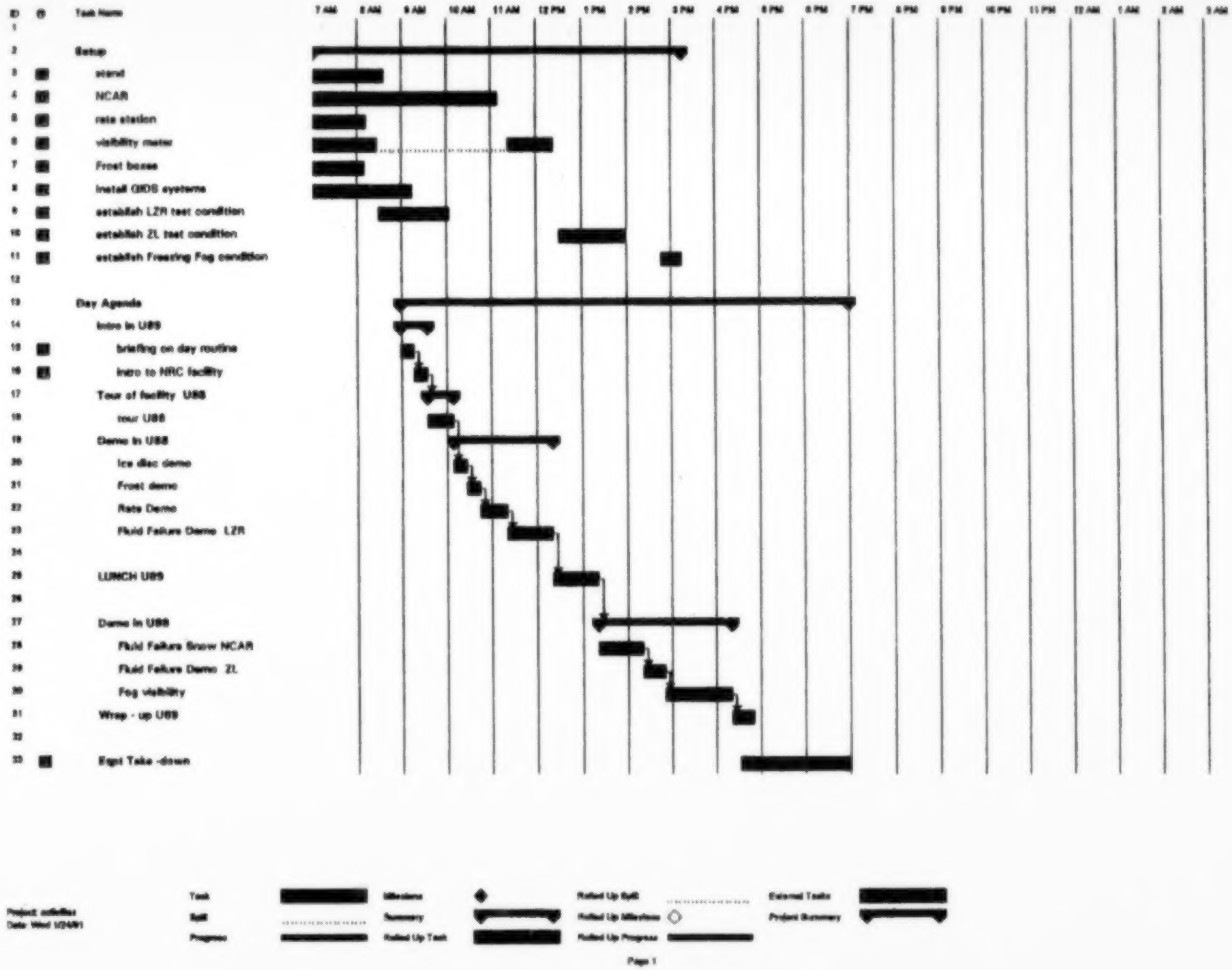
ID
Task Name
7 AM
8 AM
9 AM
10 AM
11 AM
12 PM
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
11 PM
12 AM
1 AM
2 AM
3 AM
1
2 Setup
3 stand
4 NCAR
5 rate station
6 visibility meter
7 Frost boxes
8 Install GIDS systems
9 establish LZR test condition
10 establish ZL test condition
11 establish Freezing Fog condition
12
13 Day Agenda
14 Intro in U89
15 briefing on day routine
16 Intro to NRC facility
17 Tour of facility U89
18 tour U89
19 Demo in U89
20 Ice disc demo
21 Frost demo
22 Rate Demo
23 Fluid Failure Demo LZR
24
25 LUNCH U89
26
27 Demo in U89
28 Fluid Failure Snow NCAR
29 Fluid Failure Demo ZL
30 Fog visibility
31 Wrap - up U89
32
33 Eqpt Take -down
Project: activities
Date: Wed 1/24/01
Task
Split
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Split
Rolled Up Milestone
Rolled Up Progress
External Tasks
Project Summary
Page 1

Ice Disc Making (for Ice under Fluid and Visibility tests)

Set-up

1. Set-up table for work station on far side of Cold chamber (AA)
2. Assemble Demo material (AA)
   - 3 standard plates
   - wood masks
   - Vaseline
   - Spray bottle with water
   - Caliper
   - Thickness gauge
3. Prepare 2 discs in advance of demo (ice thickness of 0.5mm); leave one with mask overlaid (AA)
4. Conduct demo (MC)

Issues and Demo Checklist (MC)

1. Describe how ice disc is made and why spray and Vaseline are used
   - Pouring water re-melts ice and runs under mask
   - Ice sticks to mask and pulls away from plate
2. Illustrate making disc by spraying
3. Demo measuring of ice thickness
   - With pin of caliper (melt through the ice with the pin end, and close the blunt end to the ice surface)
   - With thickness gauge, mention problem of splitting ice disc

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Frost Boxes

Set-up

1. At site, prepare 4 cold-soak boxes (7.5 cm deep), filling completely with 65/35 PG fluid. Pre-chill by placing in freezer. (NB)

2. On arrival at NRC on Monday, set-up freezer in cold-chamber, and put 4 boxes inside to cool overnight. Chill boxes to at least −20°C for test. (NB)

3. Set-up 1/2 stand for work station on far side of Cold chamber (AA)

4. Assemble Demo material (AA)
    - Caliper
    - Thickness gauge
    - Vaisala meter
    - Temperature probe

5. Bring boxes to stand (AA)
    - One box 20 minutes before demo to allow frost to grow
    - A second box 10 minutes before for a lesser amojunt of frost
    - A third box just at start of demo

6. Conduct demo (MC)

Issues and Demo Checklist (MC)

- Note how frost is forming on boxes; note RH and temperatures of air and box surface
- Describe test process; how sensor indication of frost triggers measurement of frost depth (peak height)
- Show how frost depth is measured

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Precipitation Rate Measurement

Set-up

1. Set-up sprayer system for ZR-, 13g/dm^2/h, -10C. NRC
2. Prepare rate station: (JK/NM/KH)
   - scale
   - computer
   - pans (1 to 6)
   - rate software
   - time stamp (standby power unit)
   - Video
   - shelves
   - clocks (Synchronize)
   - print software
   - printer
3. Pre calibration run 1 (2 pans-) (JK/NM/KH)
4. Pre calibration run 2, 3, 4.... (2 to 6 pans) (JK/NM/KH)
5. Rate Before #1 –10 minutes typically (6 pans) (JK/NM/KH)
6. Rate Before #2 (6 pans) (JK/NM/KH)
7. Conduct tests on several plates at a time (MC)
8. Run Continuous rates on one position
9. Rate after #3, 4 (JK/NM/KH)

Issues and Demo checklist (JD/JK/KH)

1. Describe equipment (pans, scale, computer, sprayer, stand 6 or 12 plates, video)
2. Give detail of process for one entry for one pan Tb, Ta , Wb, Wa, and how to compute rate
3. Go thru set-up above
4. Describe calibration time required to obtain precise rate.
5. Describe how to get rate for one test: avg of R1, R2, R3, R4
6. Demonstrate program with an example; show summary sheets
7. Tolerances
8. More......??????

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Failure Call

Set-up

1. Set-up test stand with collection system and plates under the sprayer unit (JM/MC/NB)
2. Ensure additional bare plates, for droplet size demo, are available and near stand (JM/MC)
3. Ensure fluids test fluids are prepared (JM/MC)
4. Ensure test equipment (squeegees, scrapers, plate covers etc) are located near test stand (JM/NB)
5. Set-up lights near stand (JM/NB)
6. Set-up sprayer system for ZR-, 13g/dm^2/h, -10C. (NRC)
7. Ensure rate station prepared (JK/NM)
8. Rate calibration (JK/NM/KH)
9. Set-up sprayer system for Zd, 13g/dm^2/h, -10C. (NRC)

Issues and Demo checklist (MC)

1. Describe test equipment (pans, sprayer, stand, 9 plates)
2. Droplet size description (place bare plate under precipitation for 5 seconds and remove). Save Zr- plate with frozen droplets for comparison with Zd plate in afternoon
3. Describe fluids
4. Describe plate cleaning and fluid pouring procedure
5. Go thru set-up above
6. Describe data form
7. Describe test process
    - Personnel
    - Sensors
    - When sensor first detects failure
    - End of test
8. Describe various fluid failure characteristics
9. Describe standard failure definitions (crosshairs, 30% plate failure)
10. Describe fluid thickness measurement and ice measurement procedures
11. More......??????

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NCAR Snow Maker

Set-up

1. Ensure ice cores are filled with distilled water the day prior to testing (NB)
2. Ensure NCAR plate crosshairs are marked (NB)
3. Bring two crates containing NCAR unit into chamber (NRC)
4. Set-up unit near test stand (NB)
5. Ensure fluids test fluids are prepared (NB/MC)
6. Ensure test equipment (squeegees, scrapers etc) are located near NCAR unit (NB)
7. Set-up NCAR laptop in control room (NB/MC/NM)
8. Bring 3 ice cores into control room 30 minutes prior to testing and allow to melt slightly. Remove core from tube and place in chamber to refreeze (NB)
9. Ensure all cables are attached and NCAR unit is functioning prior to onset of testing (NB/MC)
10. Put ice core into position and start program. Allow to run for 10-15 minutes to verify proper functioning of system
11. Run test (NB)
12. Type IV test before people come (NB/MC)
13. Type I test during demo (NB/MC)

Issues and Demo checklist (MC)

1. Describe test equipment (NCAR unit, scale, bucket, plate etc)
2. Describe NCAR rate procedure briefly
3. Describe ice core, stepper motor, drill, etc
4. Describe fluids
5. Describe plate cleaning and fluid pouring procedure
6. Go thru set-up above
7. Describe inputs required in computer to obtain desired rate
8. Describe data form
9. Describe test process
10. Conduct test
11. Describe various fluid failure characteristics
12. Describe standard failure definitions (crosshairs, 30% plate failure)
13. Describe fluid thickness measurement and ice measurement procedures
14. Problems:
    - temperature differential
    - door opening problem
    - size of plates

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Visibility Demo

Set-up

1. Unpack and assemble visibility meter (NM)
2. Link to laptop to ensure display of values (NM)
3. Move into cold chamber and mount on rolling stair (NM)
4. Install Laptop in office area, linked to meter. (NM)
5. Move meter about during fog demonstration as directed. (NM)
6. Generate fog visibility condition in chamber (NRC)

Issues and Demo Checklist (PD)

1. Demonstrate use of visibility meter while fog condition is being readied (NM)
2. Invite visitors to experience fog in chamber. Point out variation in visibility restriction, between sensor and stand.
3. Move visibility sensor within fogged area to show range of fog restriction.
4. Describe procedure of halting fog generation, and scanning at appropriate time while visibility clears. Stop fog generation, and show how quickly fog clears and visibility improves.

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ATTACHMENT F-VI

WG54 DEMO JAN 2001

TEST EQUIPMENT CHECKLIST

TASK	NRC Cold Chamber	
	Resp.	Status
Logistics for Every Test		
Make Hotel reservations	JD	done
Rent Cube truck in Montreal		
Personnel Advances		
Rent visibility meter		
Personnel Transportation		
Prior to Testing		
Decide on fluids based on availability at site		
Check that plates are at site		
Check that Masks are at site		
NCAR unit at site?		
Prepare all software and computers (rate/NCAR/visibility)		
Test Equipment		
Stand and plates		
New Stand x 2 (individual stands) with collection systems		
Bare aluminum plate X 6		
Polished aluminum plate X 1		
Half bare half polished aluminum plate X 1		
Painted Aluminum plate (White) X 1		
Painted Aluminum plate (Red) X 1		
Painted Aluminum plate (Red and White) X 1		
Painted Composite plate (White) X 1		
Painted Composite plate (Red) X 1		
Painted Composite plate (Red and White) X 1		
Plate covers x 6		
plate masks X 3	Mhunt	
Vaseline		
Spray bottles X 2		
Rate Equipment, Frost Display, Ice making Display		
Weigh Scale x 1 (sartorius) + wiring (2 if no site test)		
Insulation for weigh scale		
Large precipitation Pans(2 sets of 12 each)		
Microscope (with oil) for droplet sizes		
Forensic scales		
Rate Software		
Cold-soak boxes, 7.5cm X 4, filled witn 65/35 PG		
Freezer		
Measuring Instruments		
Large digital clock x 1 (2 if no site test)		
Brixometer X 2		
Hand-held Temperture Probes x 2 (Barnant and Wahl)		
Thickness Gauges x 10 (both types)		
RH meter		
Tape measure		
Visibility Meter		
Inclinometer (yellow level) X1		
Computer Equipment		
Laptop Computer x 4		

ATTACHMENT F-VI (cont.)

WG54 DEMO JAN 2001

TEST EQUIPMENT CHECKLIST

TASK	NRC Cold Chamber	
	Resp.	Status
Diskettes		
Printer (Brother) x 1		
Video and Camera Equipment		
Still digital camera		
Digital Video camera		
Time lapse Video eqpt - video camera		
- VCR		
- Monitor		
Fluids and containers		
Fluids		
Red containers for fluid		
1 litre pour containers x 6		
Funnels		
Waste containers x 4		
Paper work		
HOT Tables		
Test Procedures		
Data Forms for plates		
Precipitation rate Data Forms		
Clipboards x 5		
Pencils + pens		
Paper for printer (1 pack)		
Clean up Equipment		
Paper Towels		
Rags		
Protective clothing (6)		
Funnels		
Rubber squeegees x 4		
Scrapers		
Various other		
Electrical Extension Cords - lots		
Lighting x 4		
Storage bins for small equipment		
Tie wraps		
Spray paint		
Washers		

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CM1718.001

Explanation of Revisions to AS 5116A

Prepared for

SAE
G-12 Ice Detection Subcommittee

Prepared by: Alia Alwaid

Reviewed by: John D'Avirro

APS AVIATION INC. APS

Final Version 1.0
June 12, 2002

BACKGROUND

During the past year, a testing procedure was prepared by APS Aviation Inc. ("APS"), for a sensor manufacturer to certify their Remote Ground Ice Detection System ("GIDS"). AS 5116A was used as a guideline for writing the test procedure. A number of challenges were faced in the methodology and procedures to be followed when conducting the tests. These challenges led APS to present those issues and propose changes to AS 5116A during the recent SAE G12 Ice Detection Subcommittee meeting held on June 6, 2002.

A document entitled, 'Proposed Revisions to AS 5116A', dated May 2, 2002 was posted for the committee for review prior to the meeting. Comments and questions were received and addressed.

During the meeting, the proposed changes were presented. After extended discussions and with the consensus of the members of the subcommittee that were present, some amended changes have been proposed. The following is a brief outline of the reasons behind some of the proposed changes.

1. CONTAMINATED SURFACE TREATED WITH FLUID (AFTER DE-ICING)

Tests of *"Contaminated Surface Treated with Fluid (after De-Icing)"* call for special requirements. A method to satisfy the requirements will be recommended. Four issues are discussed:

- Tolerance on Air Temperature (see Section 1.2)
- Tolerance on Fluid Thickness (see Section 1.3)
- Start Time of Test with Type I Only (see Section 1.4)
- Proportion of Type I to Type II/Type IV (see Section 1.5)

1.1 Excerpt from AS 5116A

Section 5.3.1.3b of Chapter 5 of AS 5116A states:

"A set of tests shall be conducted at −10°C to demonstrate the capability of GIDS to identify residual ice under a fluid layer in accordance with the criteria defined in paragraph 3.1.1 b. For these tests Ethylene glycol, Diethylene glycol and Propylene glycol based fluids shall be used.

a) Develop a layer of ice on each plate, within or over the sensing area of the sensor subject to test in order to ensure a maximum thickness of 0.5 mm and a maximum area of 315 cm² of ice after the fluid application. Only for this test, and in order to ensure a significant fluid thickness over the contamination, the plates shall be horizontal.

b) The sensor, or all sensors of the GIDS involved in the test shall indicate the presence of ice.

c) Pour a Type I fluid as described in Appendix B on each test plate.

⇒ Repeat the test with a Type II and a Type IV neat and Type I followed by Type II or Type IV fluid layer of 3 mm thickness over the ice patch at the start of the GIDS observation. (As a minimum, Type I followed by Type II and IV shall be limited to only one compatible glycol base).

The fluid selection process is described in Appendix B."

1.2 Tolerance on Air Temperature

1.2.1 Explanation of Requirement

AS 5116A does not specify a tolerance for the air temperature at which the tests are being conducted.

1.2.2 Proposed Solution and Tolerances

Air temperature recommended should be −10°C +1/-2°C.

1.3 Tolerance on Fluid Thickness

1.3.1 Explanation of Requirement

AS 5116A requires that a minimum thickness of 3 mm of fluid be present when conducting tests. The quantity of Type I and Type II or Type IV fluid to be poured is not specified. Experience with fluids indicates that even if the plates are horizontal, 3 mm thickness may not be achieved. To ensure that the minimum thickness of fluid is achieved while adhering to a thickness of fluid that exists in the real world, the following solution and tolerances are proposed.

1.3.2 Proposed Solution and Tolerances

A retainer to retain the Type II/IV fluid will be placed.

Thickness of fluid above ice patch recommended should be **3.0 mm ± 0.5 mm**.

1.4 Start Time of Test with Type I Only

1.4.1 Explanation of Requirement

AS 5116A does not specify a start time for the duration of time between pouring Type I and starting the test using the sensor. To ensure that the test is conducted while an adequate amount of Type I fluid is on the test plate a time limit of 15 seconds was proposed.

1.4.2 Proposed Solution

The following text was added:

"For Type I tests, ensure that the test start is conducted within a maximum of 15 seconds from the time of pouring the fluid."

1.5 Proportion of Type I to Type II/Type IV

1.5.1 Explanation of Requirement

AS 5116A does not specify any methodology to follow that indicates the proportion of Type I fluid to Type II or Type IV. To ensure that the test is conducted while an adequate amount of Type I fluid is on the test plate in relation to Type II or Type IV, a procedure utilizing a retainer is proposed.

1.5.2 Proposed Solution

The following text was added:

"For Type II or Type IV tests, a retainer placed on the plate may be used to ensure that 3 mm ± 0.5 mm is achieved.

For Type I followed by Type II/IV, the following procedure may be used: Pour Type I, allow to drain for a maximum of 15 seconds after fluid application. Place the retainer, and pour Type II or Type IV. Ensure that 3 mm ± 0.5 mm above the ice patch is achieved. An alternative method may be used provided 3 mm ± 0.5 mm is achieved."

1.6 Proposed changes to AS 5116A

Section 5.3.1.3b of Chapter 5 of AS 5116A was changed to state the following:

"A set of tests shall be conducted at -10°C +1/-2°C to demonstrate the capability of GIDS to identify residual ice under a fluid layer in accordance with the criteria defined in paragraph 5.3.1.3 b. For these tests Ethylene glycol, Diethylene glycol and Propylene glycol based fluids shall be used.

- *Develop a layer of ice on each plate, within or over the sensing area of the sensor subject to test in order to ensure a maximum thickness of 0.5 mm and a maximum area of 315 cm² of ice after the fluid application. Only for this test, and in order to ensure a significant fluid thickness over the contamination, the plates shall be horizontal.*
- *The sensor, or all sensors of the GIDS involved in the test shall indicate the presence of ice.*
- *Pour a Type I fluid as described in Appendix B on each test plate.*
- *Repeat the test with a Type II and a Type IV neat and Type I followed by Type II or Type IV fluid layer of 3 mm ± 0.5 mm thickness over the ice patch at the start of the GIDS observation. (As a minimum, Type I followed by Type II and IV shall be limited to only one compatible glycol base).*
- *For Type I tests, ensure that the test start is conducted within a maximum of 15 seconds from the time of pouring the fluid.*
- *For Type II or Type IV tests, a retainer placed on the plate may be used to ensure that 3 mm ± 0.5 is achieved.*
- *For Type I followed by Type II/IV, the following procedure may be used: Pour Type I, allow to drain for a maximum of 15 seconds after fluid application. Place the retainer, and pour Type II or Type IV. Ensure that 3 mm ± 0.5 above the ice patch is achieved. An alternative method may be used provided 3 mm ± 0.5 mm is achieved.*

The fluid selection process is described in Appendix B."

2. TEST TO DETECT THICK ICE

Tests for *"Frozen Contamination above the Detection Threshold"* are specified in the following section.

2.1 Excerpt from AS 5116 A

Section 5.3.1.4 of Chapter 5 of AS 5116A states:

"Validate by analysis or by tests that frozen contamination on the monitored surface in excess of the detection threshold will be detected by the GIDS."

2.2 Explanation of Requirement

Tests that are required to validate that frozen contamination on monitored surfaces in excess of the detection threshold will be detected by the GIDS, are not specified in AS 5116A.

2.3 Proposed Solution

It was recommended that the fluid manufacturer specify the thickness of the ice. As there is no mention in AS 5116A of the required tests, tests will be conducted using Plates 1-6. Tests will be on bare ice. No fluid will be used. Both sensors shall be tested.

The following text was added:

"When validated by tests the following method shall be used:

Develop a layer of ice on each plate (plates 1-6). The sensor manufacturer shall declare the thickness above the detection threshold and the tolerance for testing.

The sensor, or all sensors of the GIDS involved in the test shall indicate the presence of ice."

2.4 Proposed changes to AS 5116A

Section 5.3.1.4 of Chapter 5 of AS 5116A is changed to state the following:

"Validate by analysis or by tests that frozen contamination on the monitored surface in excess of the detection threshold will be detected by the GIDS. When validated by tests the following method shall be used:

- *Develop a layer of ice on each plate (plates 1-6). The sensor manufacturer shall declare the thickness above the detection threshold and the tolerance for testing.*
- *The sensor, or all sensors of the GIDS involved in the test shall indicate the presence of ice."*

3. WATER DROPLET TEMPERATURE REQUIREMENT FOR FREEZING FOG-VISIBILITY TESTS

The water supply temperature requirement for *"Visibility Tests for Remote GIDS - Fog"* as specified by AS 5116 A is too restrictive.

3.1 Excerpt from AS 5116 A

Table 5 in Appendix B of AS 5116A requires:

Table 5 Requirements for Freezing Fog Test Equipment

Test Parameters	***Requirements***
Environmental Chamber	
Minimum volume	*7 m³ for each 300 x 500 mm test plate*
Air temperature range	*0 °C to at least -25 °C*
Minimum temperature sampling rate	*1 datum per minute*
Relative humidity	*> 40 %*
Spray Equipment	
Water supply temperature	*<2°C*
Water droplet median volume diameter	*22 µm ± 5*

3.2 Explanation of Requirement

The requirements for the water supply temperature of the spray equipment is restrictive, as water droplets at 2°C will likely freeze before they hit the ground. This is a "freezing" fog visibility test, not a "frozen" fog or snow visibility test. Freezing fog has been successfully produced at climatic chambers for Endurance Time tests at water supply temperatures that are warmer than 2°C. The intent is to achieve super cooled water droplets.

3.3 Proposed Solution and Tolerances

It is recommended that fog be produced at the water temperatures that have been adjusted to produce super cooled water droplets.

3.4 Proposed changes to AS 5116A

Table 5 in Appendix B of AS 5116A is changed to state the following:

Table 5 Requirements for Freezing Fog Test Equipment	
Test Parameters	***Requirements***
Environmental Chamber	
Minimum volume	*7 m³ for each 300 x 500 mm test plate*
Air temperature range	*0 °C to at least -25 °C*
Minimum temperature sampling rate	*1 datum per minute*
Relative humidity	*> 40 %*
Spray Equipment	
Water supply temperature	*Adjusted to produce super cooled water droplets*
Water droplet median volume diameter	*22 µm ± 5*

4. TEMPERATURE REQUIREMENT FOR NATURAL SNOW - VISIBILITY TESTS

The visibility test for snow will be conducted in natural conditions. The air temperature requirement for *"Visibility Tests for Remote GIDS – Snow"* is restrictive.

4.1 Excerpt from AS 5116 A

Table 12 in Appendix B of AS 5116A requires:

Table 12 Snow Test Conditions				
Test Condition	***SN-B***	***SN-D***	***SN-E***	***SN-V** (Visibility test for remote GIDS)*
Air temperature, °C	*-3 + 1/-2*	*-10°C ± 2*	*-10 ± 2*	*-10 ± 3*
Icing intensity, g/dm²/h	*25 ± 3.0*	*25 ± 3.0*	*10 ± 1.5*	*> 25 g/dm²/h*

4.2 Explanation of Requirement

This condition in outdoor natural snow is an infrequent occurrence. Refer to Attachment F-I for evidence that the probability of snowfall at −10°C ± 3°C is considerably lower than that at warmer temperatures.

4.3 Proposed Solution and Tolerances

It was recommended that tests be conducted whenever the snowfall rate is greater than 25 g/dm²/h, between −3°C and −10°C.

4.4 Proposed changes to AS 5116A

Table 12 in Appendix B of AS 5116A is changed to state the following:

Table 12 Snow Test Conditions				
Test Condition	***SN-B***	***SN-D***	***SN-E***	***SN-V (Visibility test for remote GIDS)***
Air temperature, °C	*-3 +1/-2*	*-10°C ± 2*	*-10 ± 2*	*-3°C to -10°C*
Icing intensity, g/dm²/h	*25 ± 3.0*	*25 ± 3.0*	*10 ± 1.5*	*> 25 g/dm²/h*

5. DEFINITION OF FZRA-B (TEMPERATURE OF -3°C VERSUS -10°C)

The condition of Light Freezing Rain (FZRA-B) is used in the conduct of various tests. Two temperature requirements are stated for this condition.

5.1 Excerpt from AS 5116A

The following Sections of AS 5116A all require that the condition of Light Freezing Rain (FZRA-B) be conducted at an air temperature of -3°C:

- Test Set 2 in Appendix A;
- Table 3 in Appendix B; and
- Table 10 in Appendix B.

However, the following section mentioned of AS 5116A requires that the same condition be conducted at an air temperature of -10°C.

- Test Set 4 in Appendix A.

5.2 Explanation of Requirement

Two temperature requirements are used to describe one condition, FZRA-B.

5.3 Proposed Solution

It will be assumed that this is a typing error. Tests listed in, Test Set 4, in Appendix A will be conducted at an air temperature of −3°C.

5.4 Proposed changes to AS 5116A

Test Set 4 in Appendix A of AS 5116 A changed to state the following:

"Air Temperature of -3°C."

6. TEMPERATURE AND PRECIPITATION REQUIREMENT FOR LIGHT FREEZING RAIN AND FREEZING DRIZZLE – VISIBILITY TESTS

Visibility tests for Light Freezing Rain and Freezing Drizzle will be conducted indoors at climatic chambers. The precipitation rate requirements for *"Visibility Tests for Remote GIDS – Light Freezing Rain and Freezing Drizzle"* are restrictive. The changes proposed will be reflected in four sections of the document. The excerpts are listed below.

6.1 Excerpts from AS 5116A

6.1.1 Excerpt 1 of 4 - Chapter 5

Section 5.3.3.3 of Chapter 5 of AS 5116A states:

"Appendix A provides a summary of all the tests that shall be performed. Test set #4 is the list of tests required for Remote GIDS visibility tests.

Conduct tests to demonstrate the ability of the remote GIDS sensor to detect an area of 315 cm² of ice on a test plate at the maximum distance of use in accordance with the conditions specified in paragraph 2.8.6.

- *Develop 0.5 mm of ice on each plate over one circular area of 315 cm².*
- *The GIDS, when inspecting the plates without precipitation, shall indicate the presence of contamination.*
- *Conduct tests with the following precipitation conditions:*
    - *FZFG-V with visual interference equivalent to a field visibility of 100 m.*
    - *SN-V between the plates and the sensor(s), and encompassing the sensor field of view.*
    - *FZDZ-B between the plates and the sensor(s), and encompassing the sensor field of view.*
    - *FZRA-B between the plates and the sensor(s), and encompassing the sensor field of view.*

Acceptance Criteria

- *The sensor(s), when inspecting the plates through active precipitation, shall continue to indicate the presence of contamination.*

Test reporting

- *Document the test procedures, precipitation rates, measurement methods and results.*

  Include the following:
    - *Distance between the GIDS and the plate.*
    - *Visibility conditions and precipitation characteristics.*

6.1.2 Excerpt 2 of 4 Appendix A- Test Set 4

Test Set 4 in Appendix A of AS 5116 A states the following:

"Test Set 4: Minimum Tests Required to Demonstrate Remote GIDS ability to 'see' under different visibility conditions

- Applicable to Remote GIDS -

Test Set: #4-1 Test Plate 7 at minimum sight angle and maximum distance.

Test #	Precip. Type	Precip. Rate (g/dm2/h)	Temperature (Deg. C)	Visibility conditions	Precip. ID.
CONTAMINATION CONDITIONS: ICE ON DRY SURFACE					
1	Fog	to be adjusted	-20	Clear / Fog Vis. < 100m	FZFG-V
2	Snow	>25	-10	Clear / Through Precip.	SN-V
3	Freezing Drizzle	13,0	-3	Clear / Through Precip.	FZDZ-B
4	Light Fr. Rain	25,0	-10	Clear / Through Precip.	FZRA-B

Sub-Total, Test set #1 = 4 tests

Test Set: #4-2 Test Plate 8 at minimum sight angle and maximum distance.
Sub-Total, Test set #2 = 4 tests

Test Set: #4-3 Test Plate 9 at minimum sight angle and maximum distance.
Sub-Total, Test set #3 = 4 tests

Total Tests: Remote Sensors (Sets 2-1,2-6): 12 Tests.

6.1.3 Excerpt 3 of 4 - Appendix B- Table 8

Table 8 in Appendix B of AS 5116A requires:

Table 8 Freezing Drizzle Test Conditions		
Test Condition	**FZDZ-B**	**FZDZ-C**
Air temperature, °C	-3 +1/-2	-10 +1/-2
Icing intensity, g/dm^2/h	13 ± 2	5 ± 1.5

6.1.4 Excerpt 4 of 4 - Appendix B- Table 10

Table 10 in Appendix B of AS 5116A requires:

Table 10 Light Freezing Rain Test Conditions		
Test Condition	**FZRA-B**	**FZRA-C**
Air temperature, °C	-3 +1/-2	-10 ± 1
Icing intensity, g/dm^2/h	25 ± 3.0	13 ± 1.5

6.2 Explanation of Requirement

It is required to test sensors at a precipitation rate of 13 $g/dm^2/h$ ± 2 $g/dm^2/h$ for Freezing Drizzle and 25 $g/dm^2/h$ ± 3 $g/dm^2/h$ for Light Freezing Rain. The tolerances that are specified are too restrictive.

6.3 Proposed Solution and Tolerances

It is recommended that tests be conducted at a precipitation rate that is greater than 13 $g/dm^2/h$ (to represent Freezing Drizzle) and a precipitation rate that is greater than 25 $g/dm^2/h$ (to represent Light Freezing Rain). Two new designations will be created to represent the two new conditions. The two new conditions are FZDZ-V and FZRA-V.

6.4 Proposed changes to AS 5116A

6.4.1 Excerpt 1 of 4 - Chapter 5

Section 5.3.3.3 of Chapter 5 of AS 5116A to be changed to state the following:

"Appendix A provides a summary of all the tests that shall be performed. Test set #4 is the list of tests required for Remote GIDS visibility tests.

Conduct tests to demonstrate the ability of the remote GIDS sensor to detect an area of 315 cm^2 of ice on a test plate at the maximum distance of use in accordance with the conditions specified in paragraph 2.8.6.

- *Develop 0.5 mm of ice on each plate over one circular area of 315 cm^2.*
- *The GIDS, when inspecting the plates without precipitation, shall indicate the presence of contamination.*
- *Conduct tests with the following precipitation conditions:*
  - *FZFG-V with visual interference equivalent to a field visibility of 100 m.*
  - *SN-V between the plates and the sensor(s), and encompassing the sensor field of view.*
  - *FZDZ-V between the plates and the sensor(s), and encompassing the sensor field of view.*

- *FZRA-V between the plates and the sensor(s), and encompassing the sensor field of view.*

__Acceptance Criteria__

- *The sensor(s), when inspecting the plates through active precipitation, shall continue to indicate the presence of contamination.*

__Test Reporting__

- *Document the test procedures, precipitation rates, measurement methods and results.*

  Include the following:

  - *Distance between the GIDS and the plate.*
  - *Visibility conditions and precipitation characteristics."*

6.4.2 Excerpt 2 of 4 - Appendix A- Test Set 4

Test Set 4 in Appendix A of AS 5116 A is to be changed to state the following:

"Test Set 4: Minimum Tests Required to Demonstrate Remote GIDS ability to 'see' under different visibility conditions

- Applicable to Remote GIDS -

Test Set: #4-1 Test Plate 7 at minimum sight angle and maximum distance.

Test #	*Precip. Type*	*Precip. Rate (g/dm2/h)*	*Temperature (Deg. C)*	*Visibility conditions*	*Precip. ID.*
CONTAMINATION CONDITIONS: ICE ON DRY SURFACE					
5	*Fog*	*to be adjusted*	*-20*	*Clear / Fog Vis. < 100m*	*FZFG-V*
6	*Snow*	*>25*	*-10*	*Clear / Through Precip.*	*SN-V*
7	*Freezing Drizzle*	*>13,0*	*-3*	*Clear / Through Precip.*	*FZDZ-V*
8	*Light Fr. Rain*	*>25,0*	*--3*	*Clear / Through Precip.*	*FZRA-V*

Sub-Total, Test set #1 = 4 tests

Test Set: #4-2 Test Plate 8 at minimum sight angle and maximum distance.
Sub-Total, Test set #2 = 4 tests

Test Set: #4-3 Test Plate 9 at minimum sight angle and maximum distance.
Sub-Total, Test set #3 = 4 tests

Total Tests: Remote Sensors (Sets 2-1,2-6): 12 Tests."

6.4.3 Excerpt 3 of 4- Appendix B- Table 8

Table 8 in Appendix B of AS 5116A to be changed to state the following:

Table 8 Freezing Drizzle Test Conditions			
Test Condition	***FZDZ-B***	***FZDZ-C***	***FZDZ-V***
Air temperature, °C	*-3 + 1/-2*	*-10 + 1/-2*	*-3 + 1/-2*
Icing intensity, g/dm²/h	*13 ± 2*	*5 ± 1.5*	*>13*

6.4.4 Excerpt 4 of 4 - Appendix B- Table 10

Table 10 in Appendix B of AS 5116A to be changed to state the following:

Table 10 Light Freezing Rain Test Conditions			
Test Condition	***FZRA-B***	***FZRA-C***	***FZRA-V***
Air temperature, °C	*-3 + 1/-2*	*-10 ± 1*	*-3 + 1/-2*
Icing intensity, g/dm²/h	*25 ± 3.0*	*13 ± 1.5*	*>25*

7. FZRA-C IN BEFORE DE-ICING TESTS OF FROZEN CONTAMINATION DETECTION

Tests of *"Untreated Surface Subject to Precipitation (Before De-Icing)"* are listed in Appendix A of AS 5116A. The conditions that are listed are FROST, FZDZ-C, FZRA-C and SN-B. The *text* describing those tests does not have mention of tests that are run in FZRA-C. It will be assumed that this is a typing error.

7.1 Excerpt from AS 5116A

Section 5.3.1.3.a of Chapter 5 of AS 5116A states:

"A set of tests shall be conducted to demonstrate the capability of GIDS to identify Frost (test FROST/FO), Ice (test FZDZ-C/FO) and Snow (test SN-B/FO) under simulated operating weather conditions in accordance with conditions given in the test matrix of the Appendix B – Table 3.

- *Conduct tests FROST/FO, FZDZ-C/FO and SN-B/FO.*
- *Each time contamination is first detected by a GIDS sensor, measure and record the thickness of frost at the time of detection (test FROST/FO), ice (tests FZDZ-C/FO) or snow (test SN-B/FO).*

  End of test occurs when the GIDS first detects the contamination or when the monitored surface is covered with a contaminated area greater than 315cm² and with a thickness greater than 0.5 mm.

Acceptance Criteria

- *For tests FROST/FO, and FZDZ-C/FO, the contamination thickness measured shall not exceed the threshold criteria as defined in paragraph 3.1.*

  For test SN-B/FO and in accordance with paragraph 3.1, there are no threshold thickness criteria for snow. However, the detection threshold thickness shall be measured and reported.

Test Reporting

- *Document the test procedures, thickness measurement methods and results for each test conducted."*

7.2 Explanation of Requirement

The text describes tests that must be conducted in only three precipitation conditions: frost, freezing drizzle, and snow. However, Appendix A on of AS 5116A calls for tests to be run in Light Freezing rain also.

7.3 Proposed Solution and Tolerances

Tests must be run in all four conditions, Frost, Light Freezing Rain, Freezing Drizzle and Snow.

7.4 Proposed changes to AS 5116A

Section 5.3.1.3.a of Chapter 5 of AS 5116A is to be changed to state the following:

"A set of tests shall be conducted to demonstrate the capability of GIDS to identify Frost (test FROST/FO), Ice (test FZDZ-C/FO and FZRA-C/FO) and Snow (test SN-B/FO) under simulated operating weather conditions in accordance with

conditions given in the test matrix of the Appendix B – Table 3.

- *Conduct tests FROST/FO, FZDZ-C/FO, FZRA-C/FO and SN-B/FO.*
- *Each time contamination is first detected by a GIDS sensor, measure and record the thickness of frost at the time of detection (test FROST/FO), ice (tests FZDZ-C/FO and FZRA-C/FO) or snow (test SN-B/FO).*

  End of test occurs when the GIDS first detects the contamination or when the monitored surface is covered with a contaminated area greater than 315cm² and with a thickness greater than 0.5 mm.

Acceptance Criteria

- *For tests FROST/FO, FZRA-C/FO and FZDZ-C/FO, the contamination thickness measured shall not exceed the threshold criteria as defined in paragraph 3.1.*
- *For test SN-B/FO and in accordance with paragraph 3.1, there are no threshold thickness criteria for snow. However, the detection threshold thickness shall be measured and reported.*

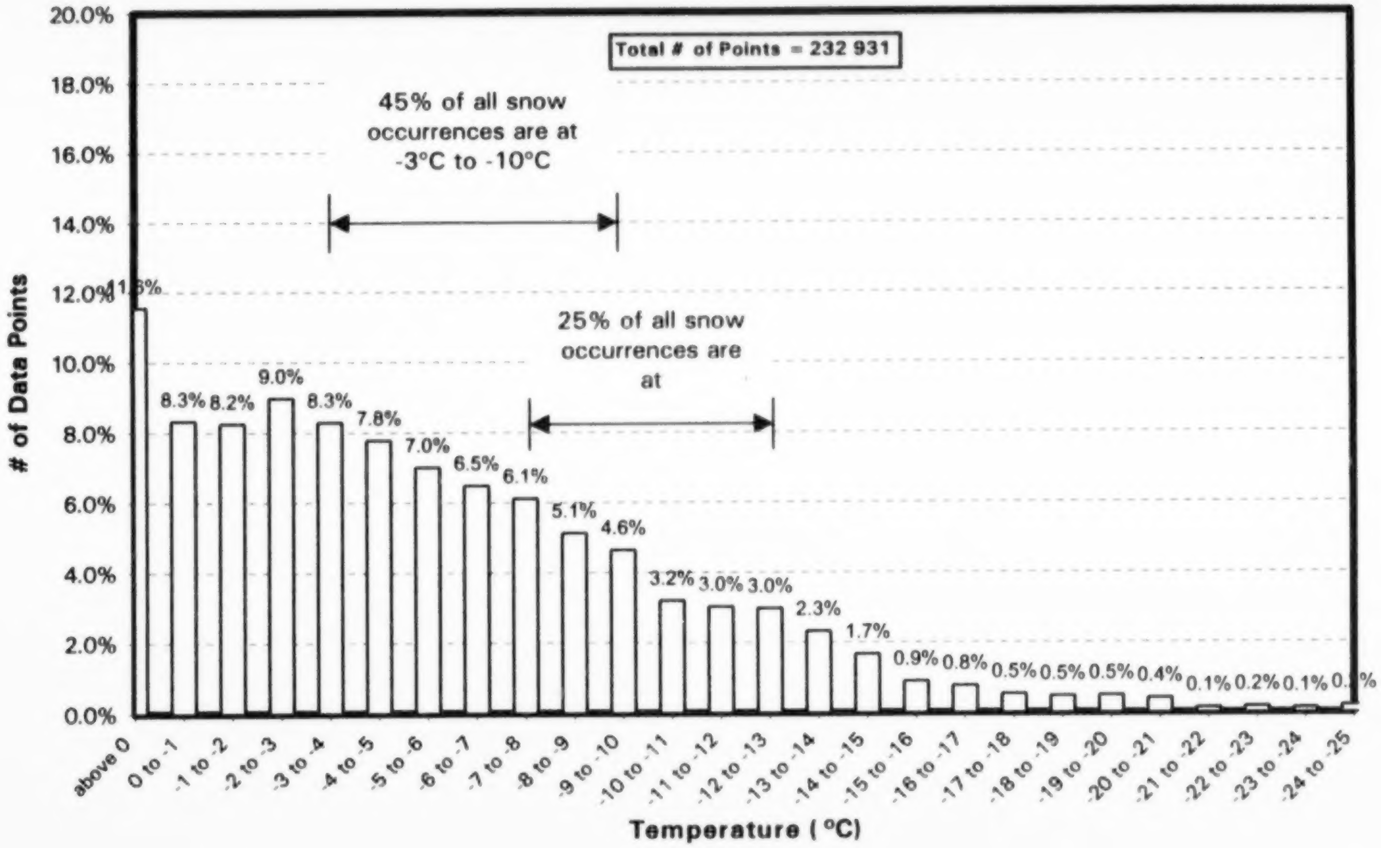
Test Reporting

- *Document the test procedures, thickness measurement methods and results for each test conducted."*

Attachment F-I

TEMPERATURE DISTRIBUTION

Natural Snow 1995 to 2002



APPENDIX G

PRESENTATIONS

SAE G-12 Holdover Time Subcommittee Meeting,
Montreal, November 2001

SAE G-12 Holdover Time Subcommittee Working Group Meeting,
Montreal, May 2002

SAE G-12 Committee,
Aircraft Ground De-icing/AEA de-icing/Anti-icing Working Group Meetings,
Frankfurt, June 2002

Presentation Index

This appendix contains copies of the following presentations:

1. Holdover Times for Forced Air Applications.
2. Effect of Fluid Strength and Dilution Rates on SAE Type I Fluid Endurance Times.
3. Type I Fluid Endurance Time Tests Using New Protocol.
4. Type I Fluid Endurance Time Tests at -3°C.
5. Aircraft De/Anti-Icing Fluid Endurance Time Results from 2001-02 Tests (for HOT Subcommittee).
6. Type I Fluid Endurance Time Tests Using New Protocol (for HOT Subcommittee).
7. Frost Contamination – Countermeasure Development Opportunities (for Future Technologies Subcommittee).
8. Test Program – Forced Air Systems Type II/IV Fluid Applied Over or Injected Into the Forced Air Stream (for Equipment subcommittee).
9. Test Program – Forced Air Systems Type I Fluid Applied Over or Injected Into the Forced Air Stream (for Equipment Subcommittee).
10. Operational Guidelines for On-Wing Thickness of SAE Type II / IV Fluids (for HOT and Methods Subcommittee).
11. Proposed Revisions to AS 5116A (for Ice Detection Subcommittee).
12. Aircraft Deicing with Forced Air.

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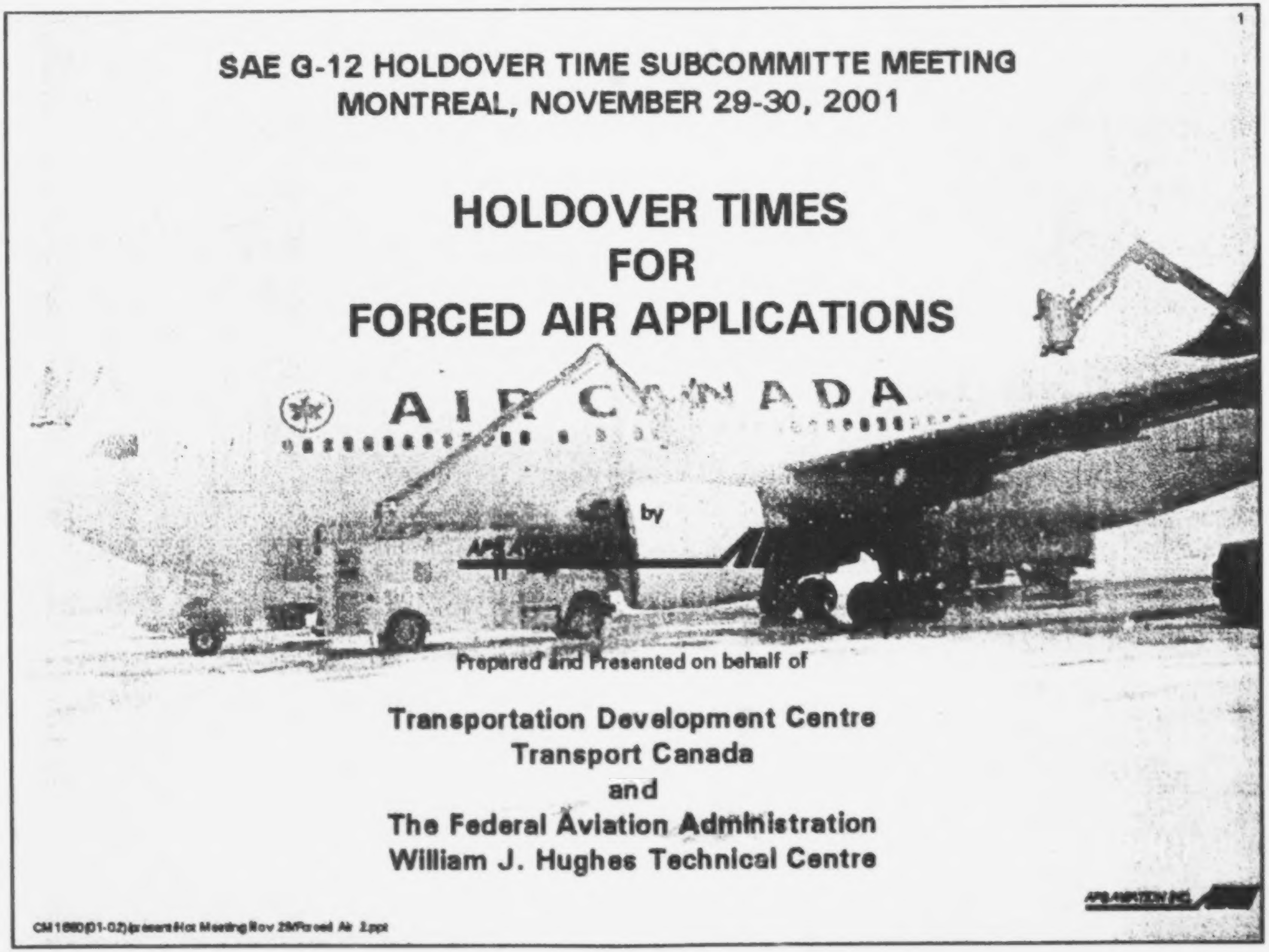

1

SAE G-12 HOLDOVER TIME SUBCOMMITTE MEETING
MONTREAL, NOVEMBER 29-30, 2001

HOLDOVER TIMES
FOR
FORCED AIR APPLICATIONS

AIR CANADA

by

Prepared and Presented on behalf of

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
William J. Hughes Technical Centre

APS AVIATION INC.

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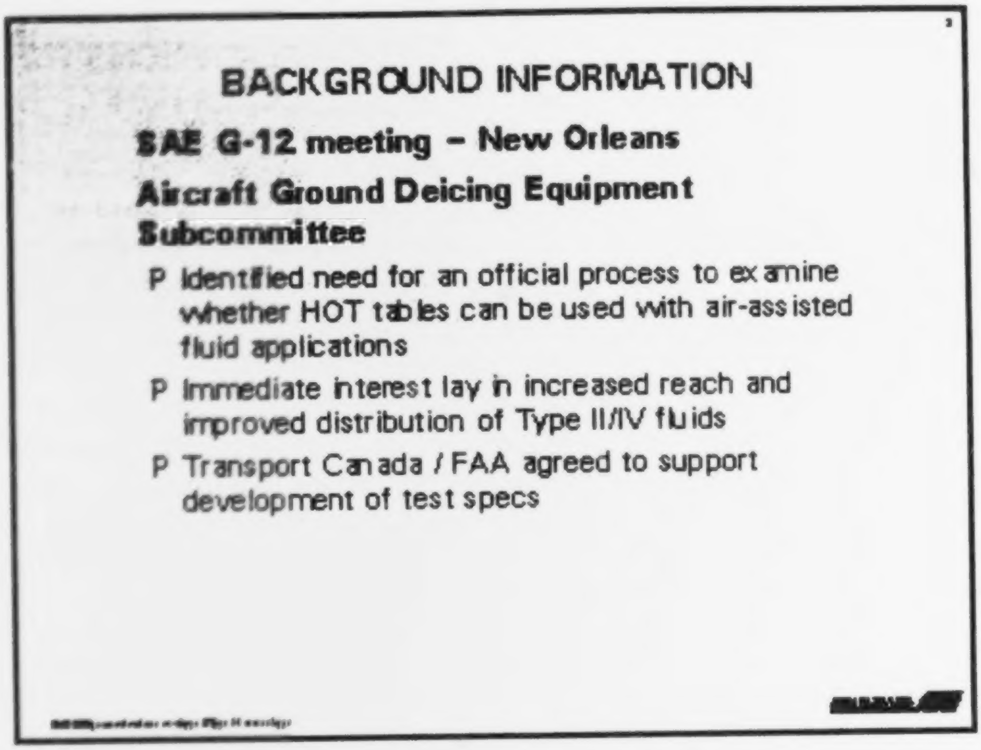


BACKGROUND INFORMATION

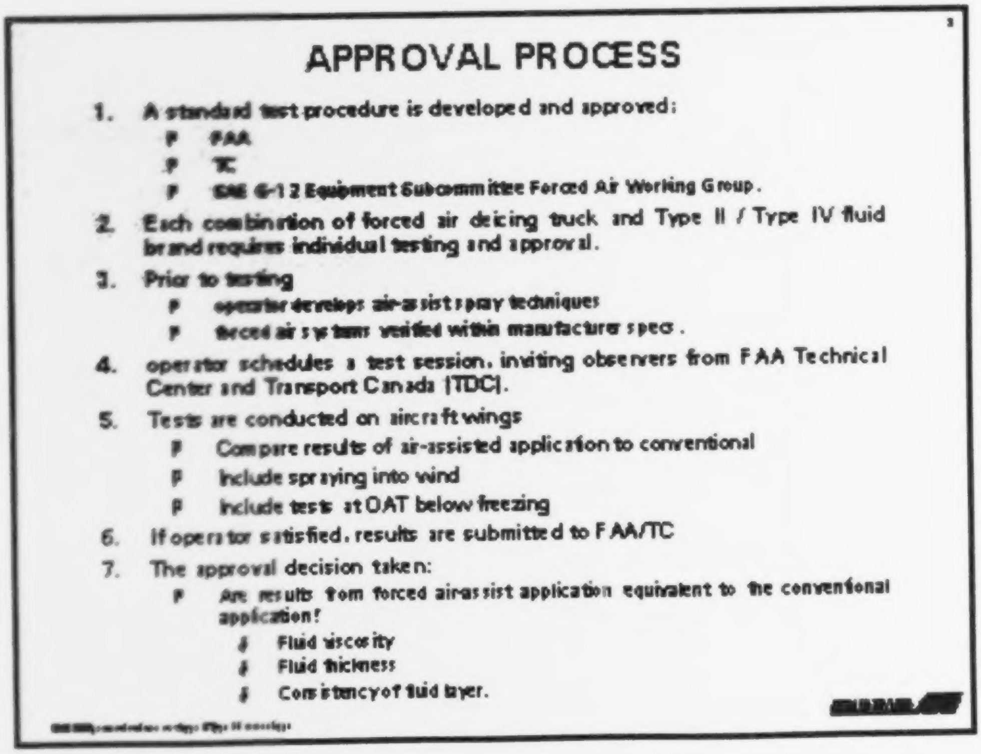
SAE G-12 meeting – New Orleans

Aircraft Ground Deicing Equipment Subcommittee

P Identified need for an official process to examine whether HOT tables can be used with air-assisted fluid applications

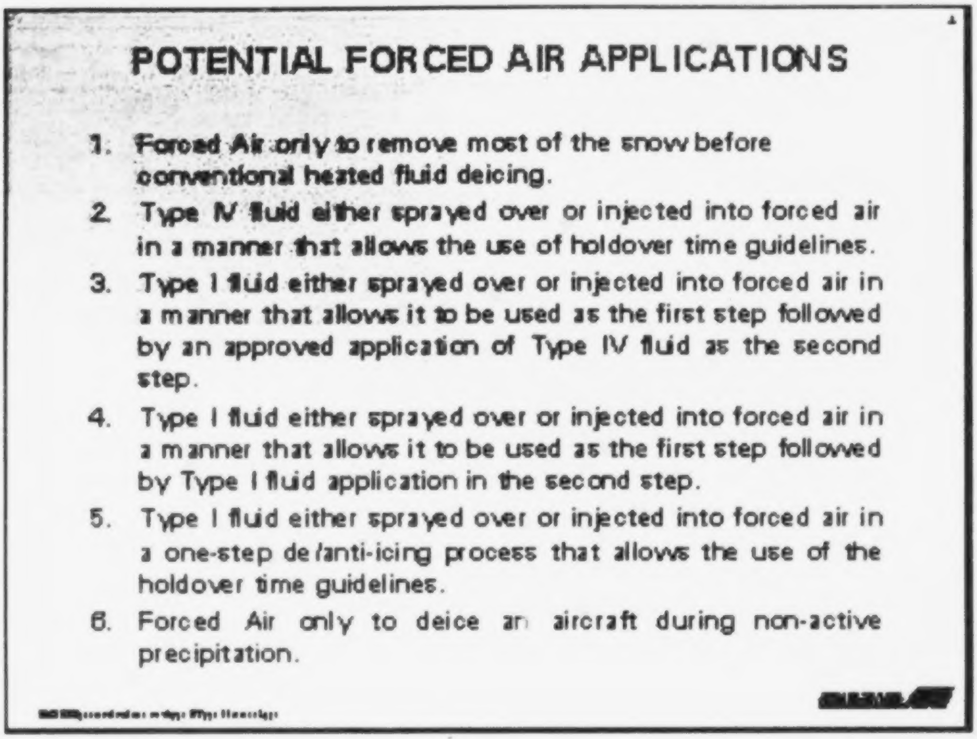
P Immediate interest lay in increased reach and improved distribution of Type II/IV fluids

P Transport Canada / FAA agreed to support development of test specs



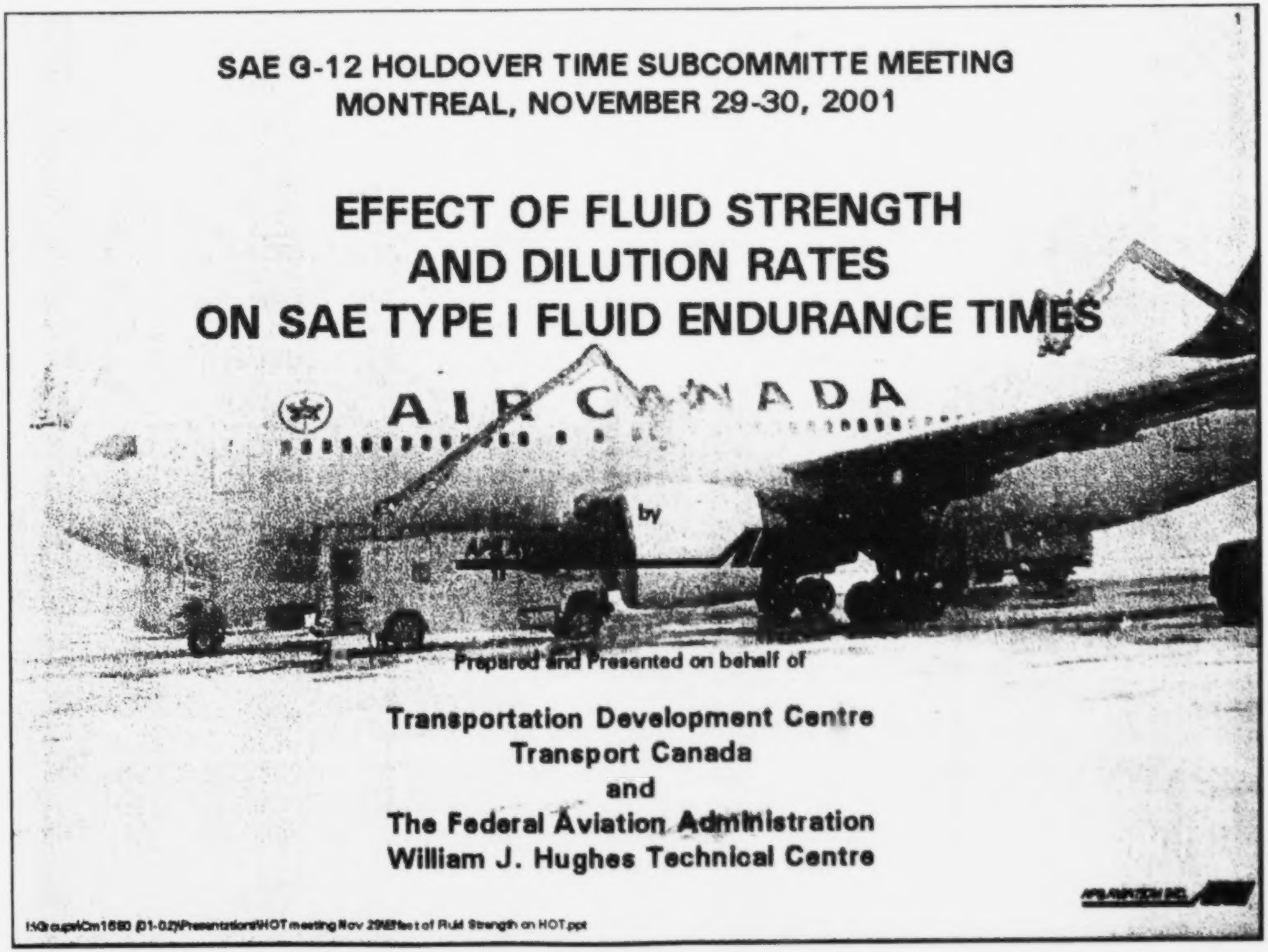
APPROVAL PROCESS

1. A standard test procedure is developed and approved:
   - P FAA
   - P TC
   - P SAE G-12 Equipment Subcommittee Forced Air Working Group.
2. Each combination of forced air deicing truck and Type II / Type IV fluid brand requires individual testing and approval.
3. Prior to testing
   - P operator develops air-assist spray techniques
   - P forced air systems verified within manufacturer specs.
4. operator schedules a test session, inviting observers from FAA Technical Center and Transport Canada (TDC).
5. Tests are conducted on aircraft wings
   - P Compare results of air-assisted application to conventional
   - P Include spraying into wind
   - P Include tests at OAT below freezing
6. If operator satisfied, results are submitted to FAA/TC
7. The approval decision taken:
   - P Are results from forced air-assist application equivalent to the conventional application?
     - § Fluid viscosity
     - § Fluid thickness
     - § Consistency of fluid layer.



POTENTIAL FORCED AIR APPLICATIONS

1. Forced Air only to remove most of the snow before conventional heated fluid deicing.
2. Type IV fluid either sprayed over or injected into forced air in a manner that allows the use of holdover time guidelines.
3. Type I fluid either sprayed over or injected into forced air in a manner that allows it to be used as the first step followed by an approved application of Type IV fluid as the second step.
4. Type I fluid either sprayed over or injected into forced air in a manner that allows it to be used as the first step followed by Type I fluid application in the second step.
5. Type I fluid either sprayed over or injected into forced air in a one-step de/anti-icing process that allows the use of the holdover time guidelines.
6. Forced Air only to deice an aircraft during non-active precipitation.



1

SAE G-12 HOLDOVER TIME SUBCOMMITTE MEETING
MONTREAL, NOVEMBER 29-30, 2001

EFFECT OF FLUID STRENGTH AND DILUTION RATES ON SAE TYPE I FLUID ENDURANCE TIMES

AIR CANADA

by

Prepared and Presented on behalf of

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
William J. Hughes Technical Centre

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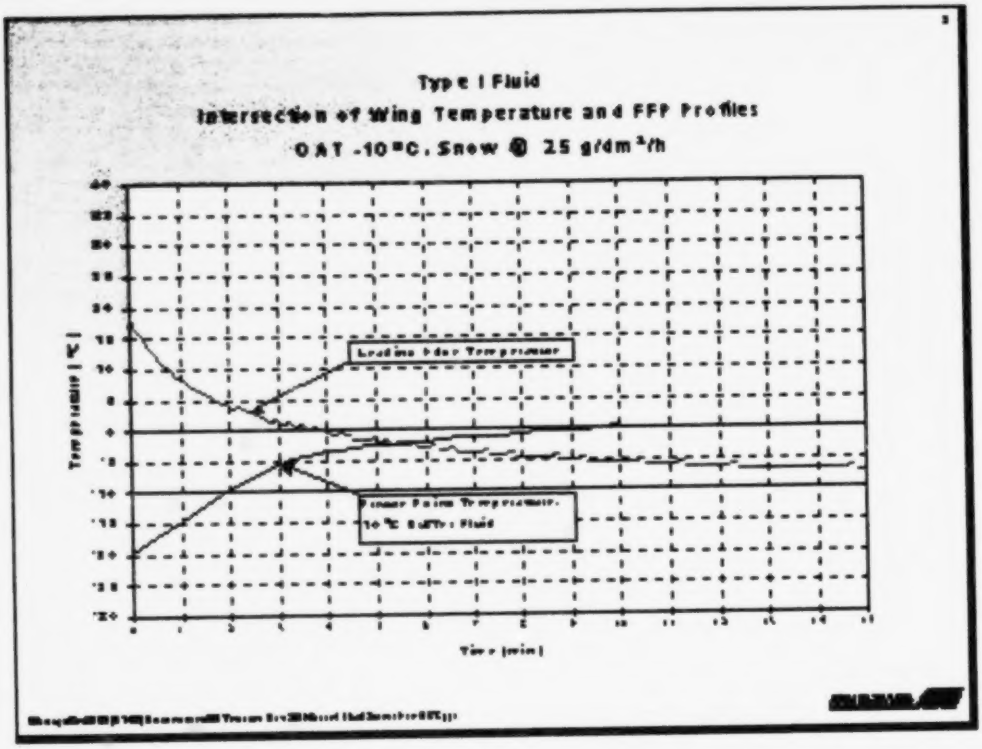
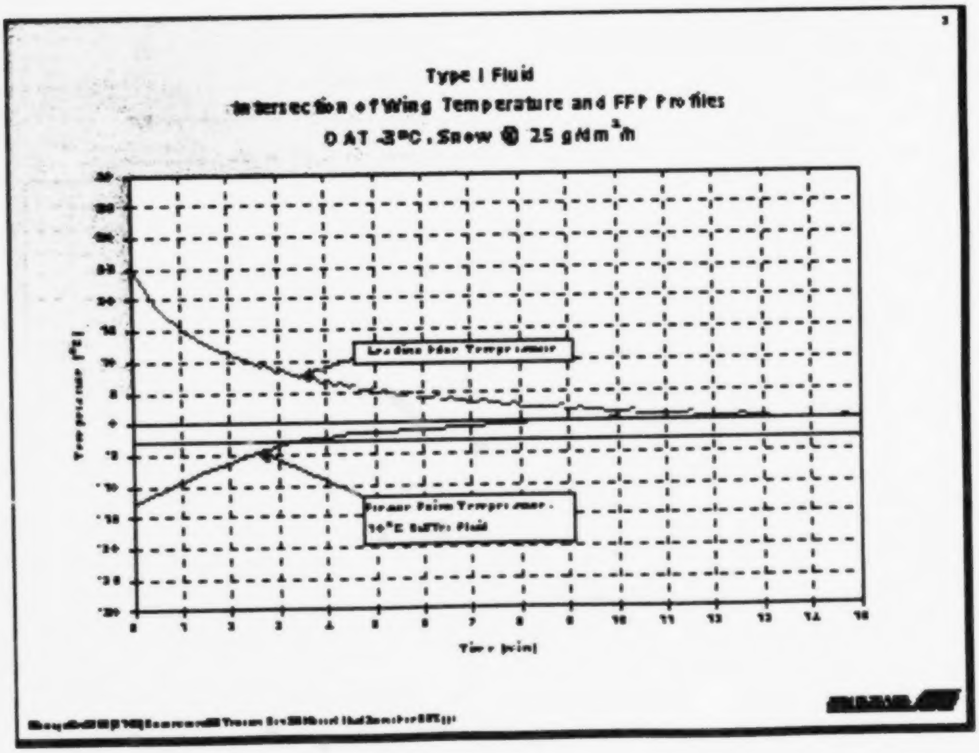
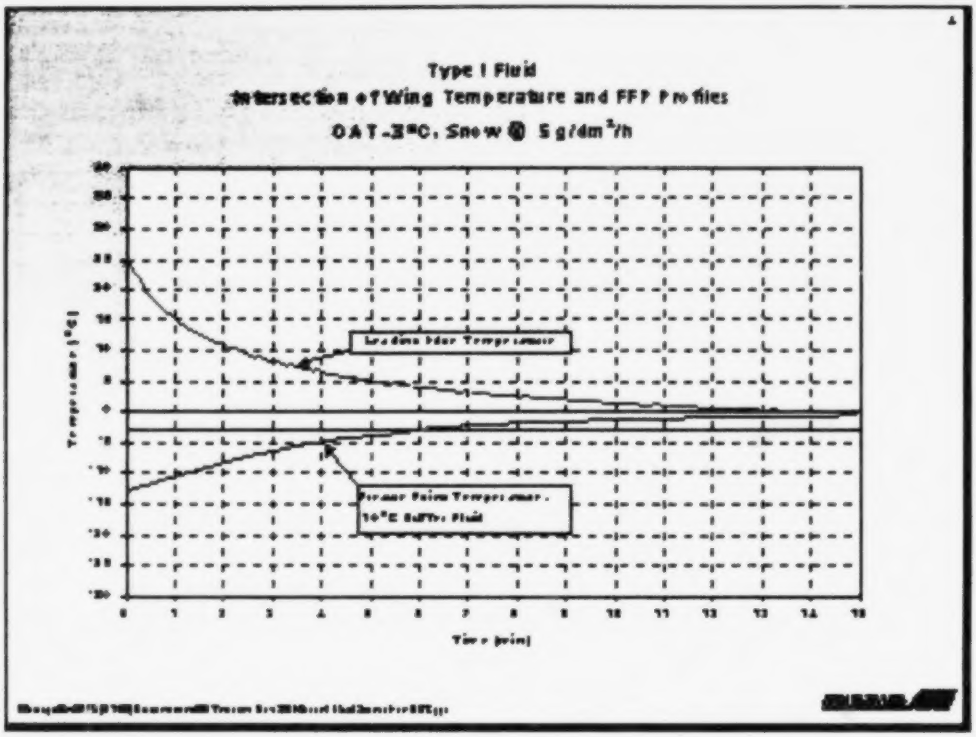
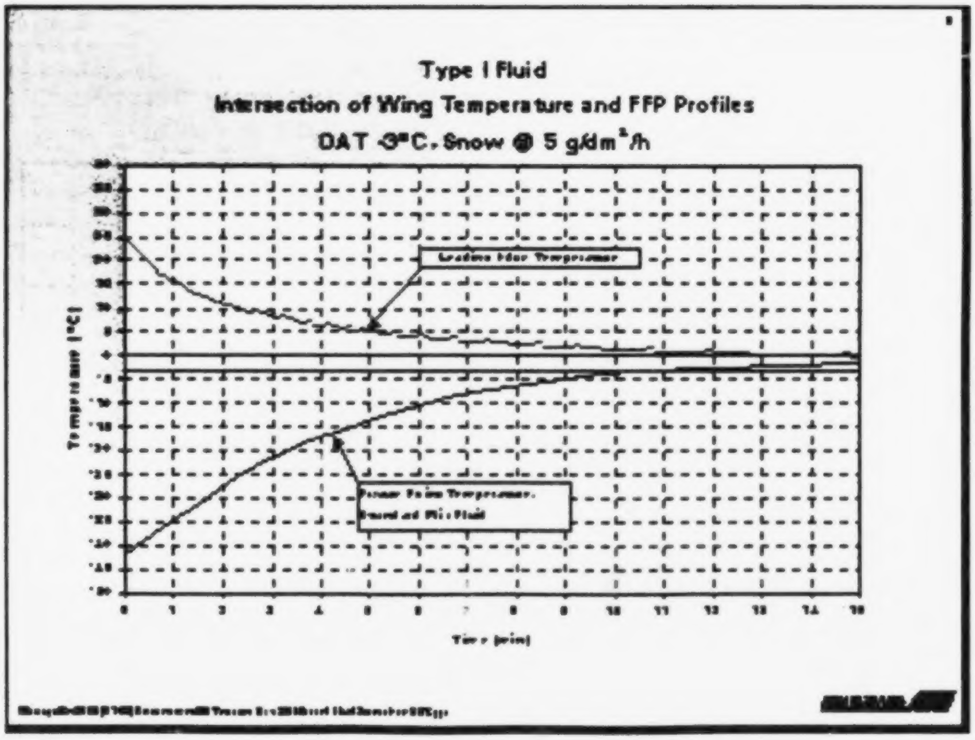

Type I Fluid
Intersection of Wing Temperature and FFP Profiles
OAT -10°C, Snow @ 25 g/dm²/h


Type I Fluid
Intersection of Wing Temperature and FFP Profiles
OAT -3°C, Snow @ 25 g/dm²/h


A
Type I Fluid
Intersection of Wing Temperature and FFP Profiles
OAT -3°C, Snow @ 5 g/dm²/h
Temperature (°C)
10
5
0
Leading Edge Temperature
Freezing Point Temperature,
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Time (min)


B
Type I Fluid
Intersection of Wing Temperature and FFP Profiles
OAT -3°C, Snow @ 5 g/dm²/h
Temperature (°C)
Leading Edge Temperature
Freezing Point Temperature,
0
1
2
3
4
5
6
7
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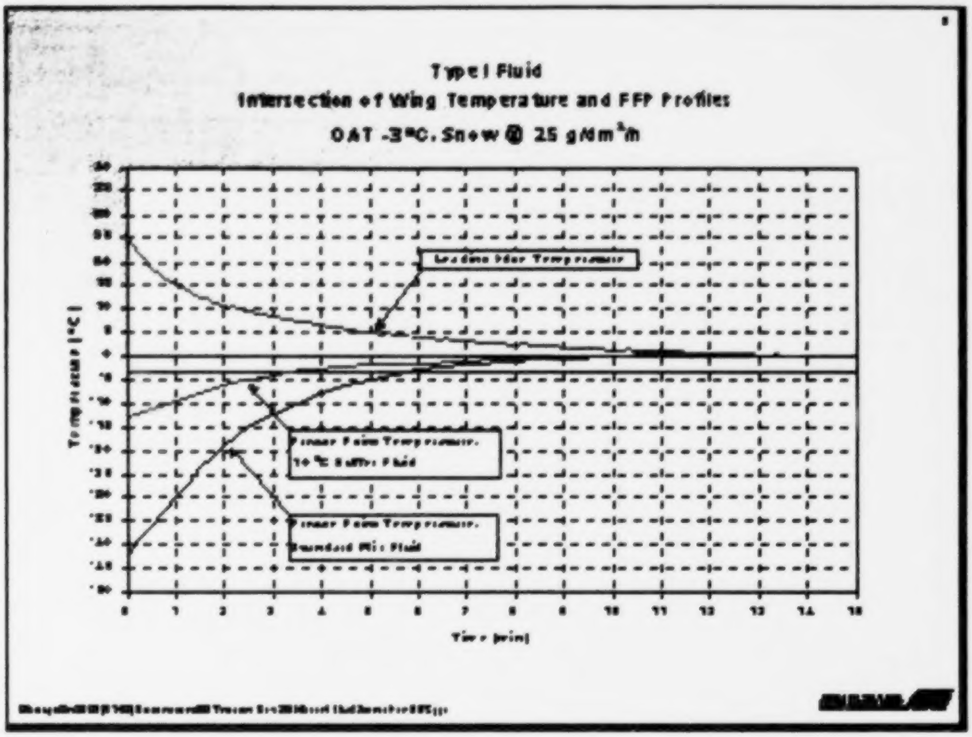
11
12
13
14
15
Time (min)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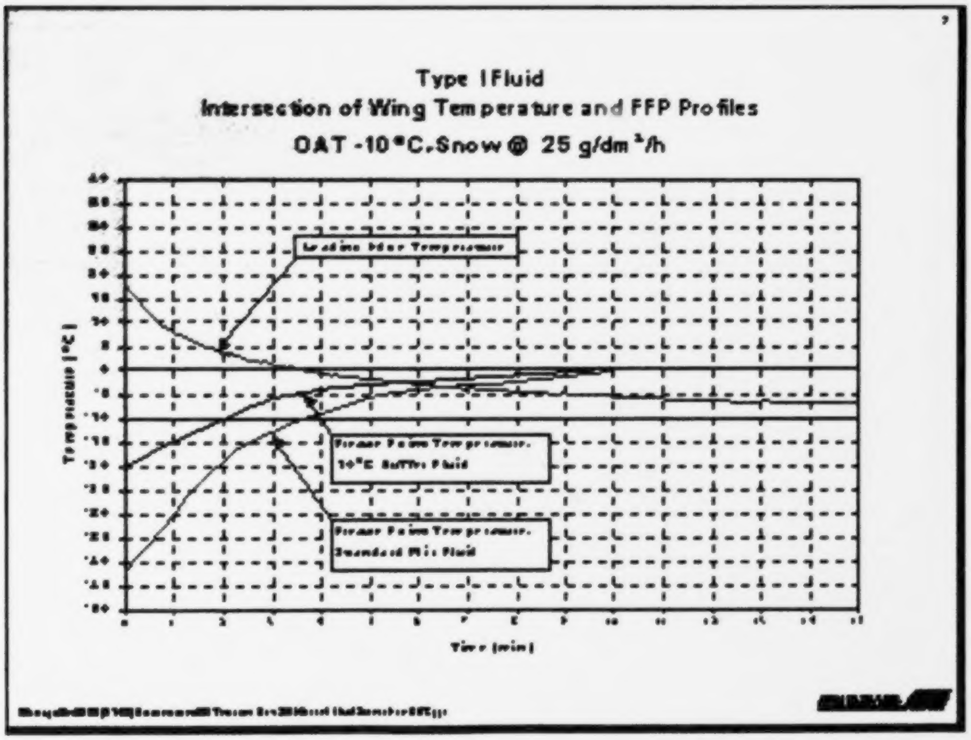
Intersection of Wing Temperature and FFP Profiles
OAT -3°C, Snow @ 25 g/dm²/h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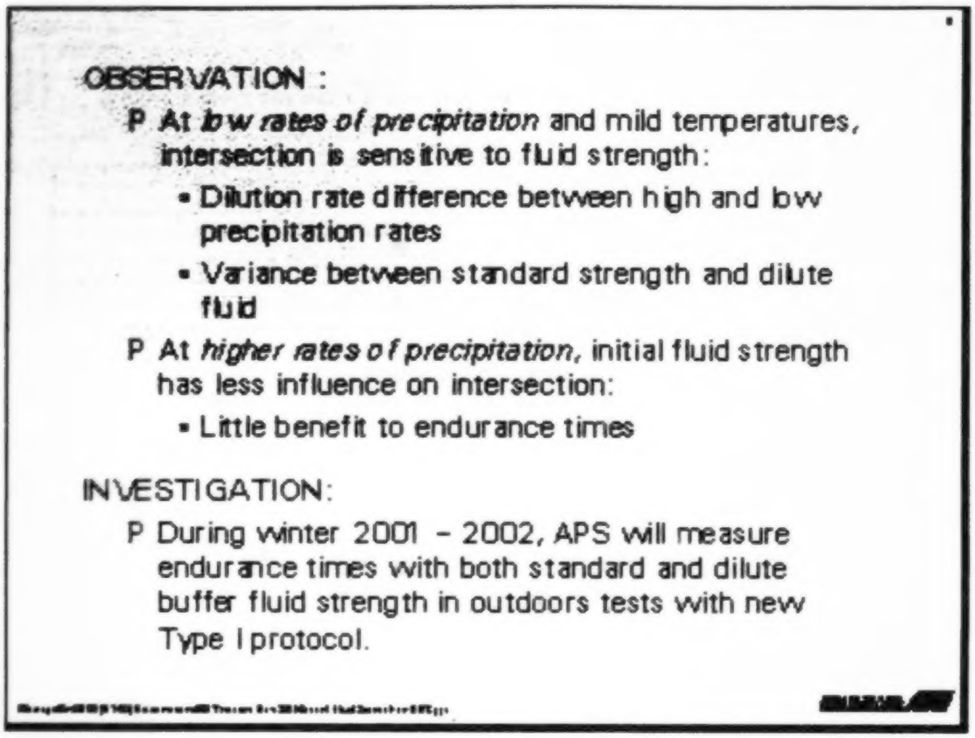
Intersection of Wing Temperature and FFP Profiles
OAT -10°C, Snow @ 25 g/dm²/h



OBSERVATION :

P At *low rates of precipitation* and mild temperatures, intersection is sensitive to fluid strength:

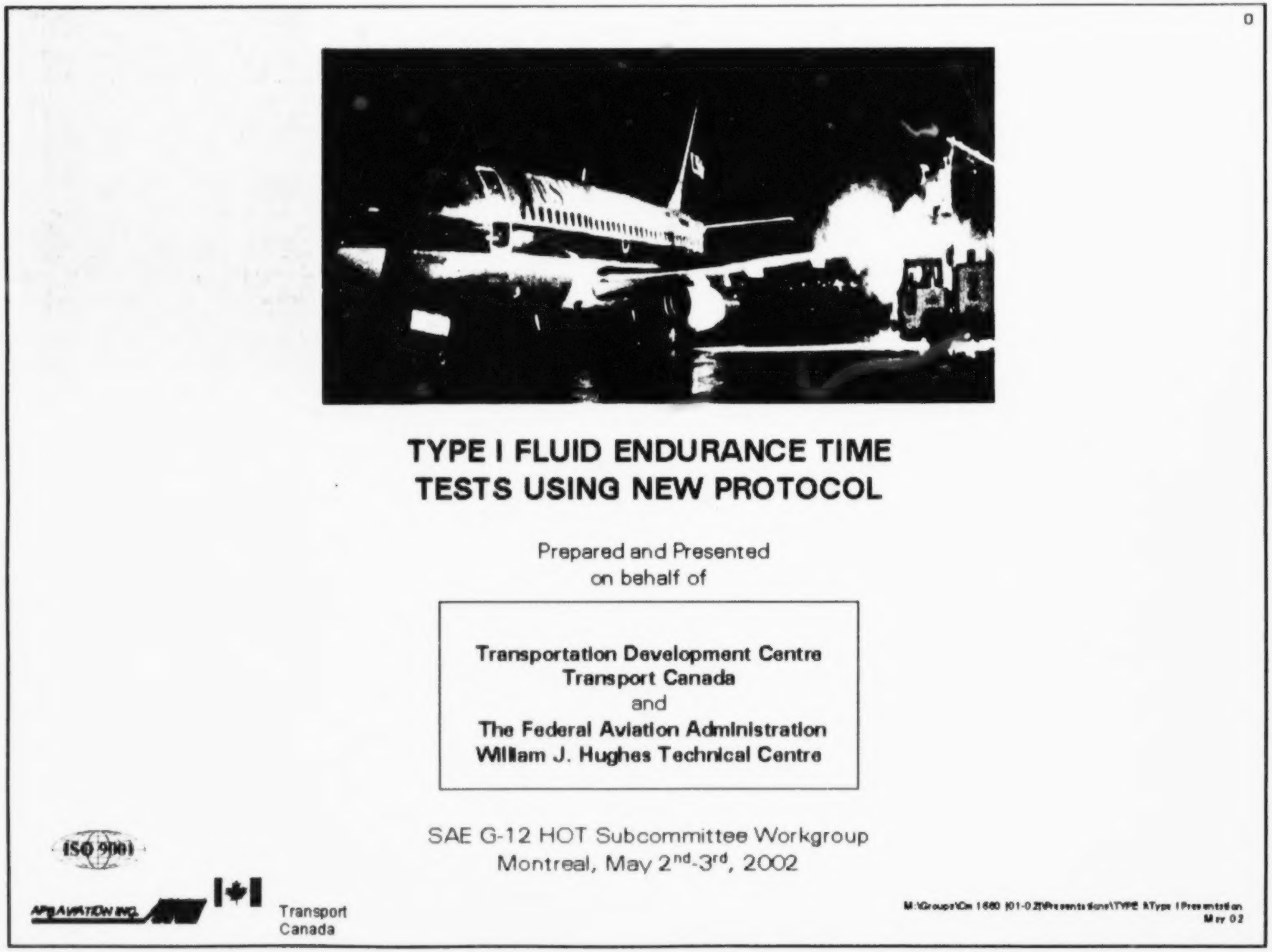
- Dilution rate difference between high and low precipitation rates
- Variance between standard strength and dilute fluid

P At *higher rates of precipitation*, initial fluid strength has less influence on intersection:

- Little benefit to endurance times

INVESTIGATION:

P During winter 2001 - 2002, APS will measure endurance times with both standard and dilute buffer fluid strength in outdoors tests with new Type I protocol.



TYPE I FLUID ENDURANCE TIME TESTS USING NEW PROTOCOL

Prepared and Presented
on behalf of

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
William J. Hughes Technical Centre

SAE G-12 HOT Subcommittee Workgroup
Montreal, May 2nd-3rd, 2002

ISO 9001

APS AVIATION INC.

Transport
Canada

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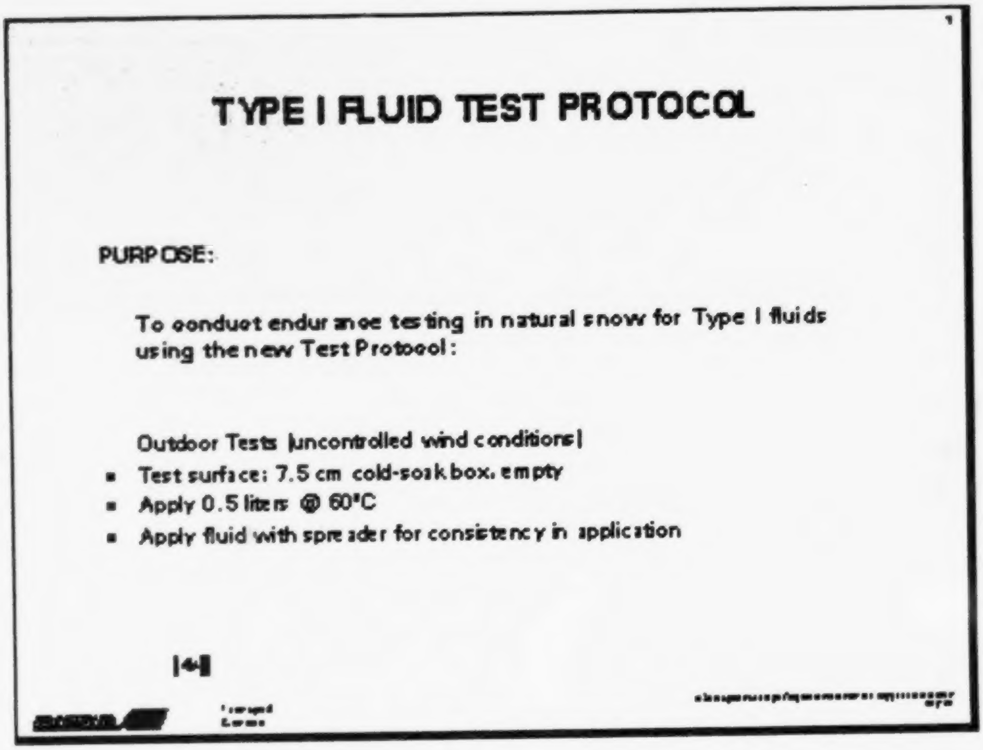

1

TYPE I FLUID TEST PROTOCOL

PURPOSE:

To conduct endurance testing in natural snow for Type I fluids using the new Test Protocol:

Outdoor Tests [uncontrolled wind conditions]

- Test surface: 7.5 cm cold-soak box, empty
- Apply 0.5 liters @ 60°C
- Apply fluid with spreader for consistency in application

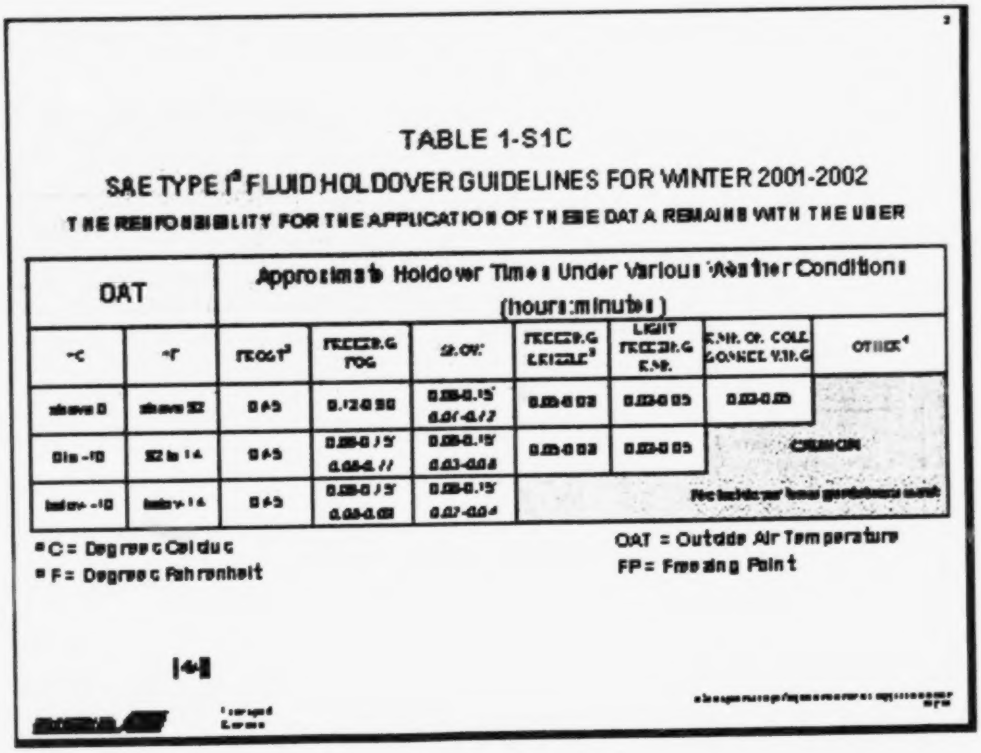

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TABLE 1-S1C

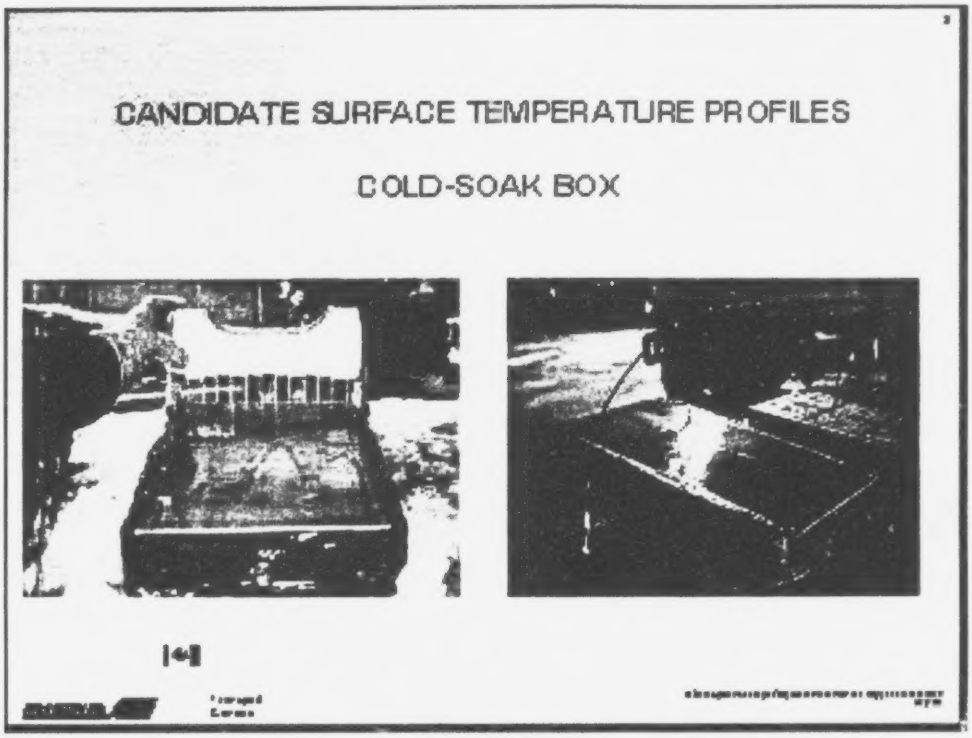
SAE TYPE I[1] FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[3]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[4]
above 0	above 32	0:45	0:12-0:30	0:06-0:15 0:01-0:12	0:05-0:08	0:02-0:05	0:02-0:05	CAUTION No holdover time guidelines exist
0 to -10	32 to 14	0:45	0:06-0:15 0:06-0:11	0:06-0:15 0:03-0:08	0:05-0:08	0:02-0:05		
below -10	below 14	0:45	0:06-0:15 0:06-0:09	0:06-0:15 0:02-0:04				

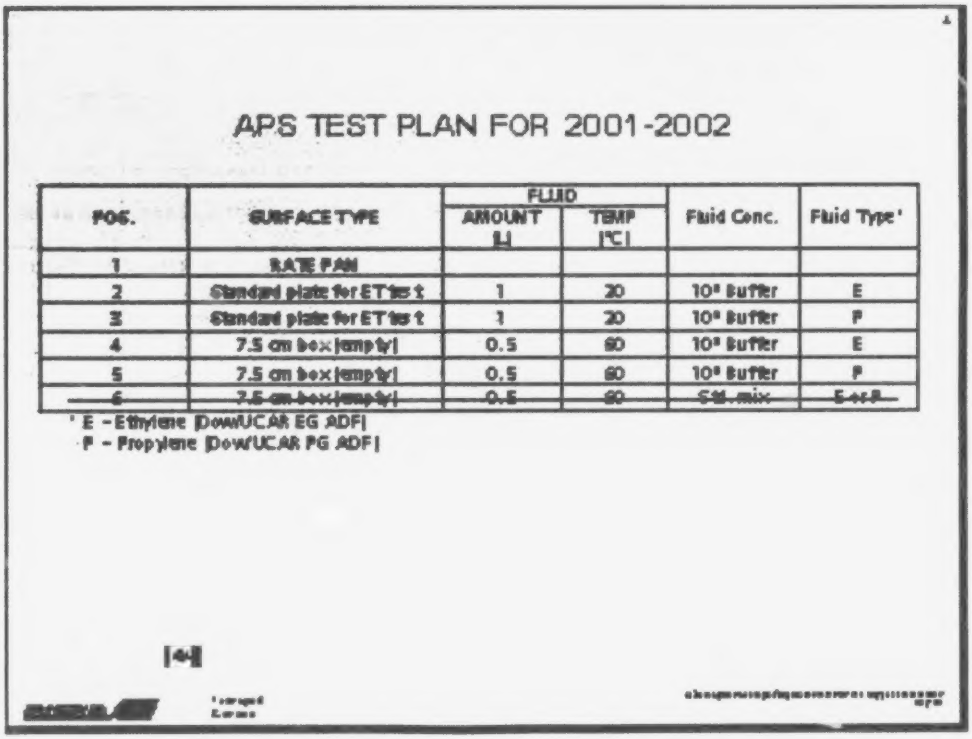
°C = Degrees Celsius
°F = Degrees Fahrenheit

OAT = Outside Air Temperature
FP = Freezing Point



CANDIDATE SURFACE TEMPERATURE PROFILES

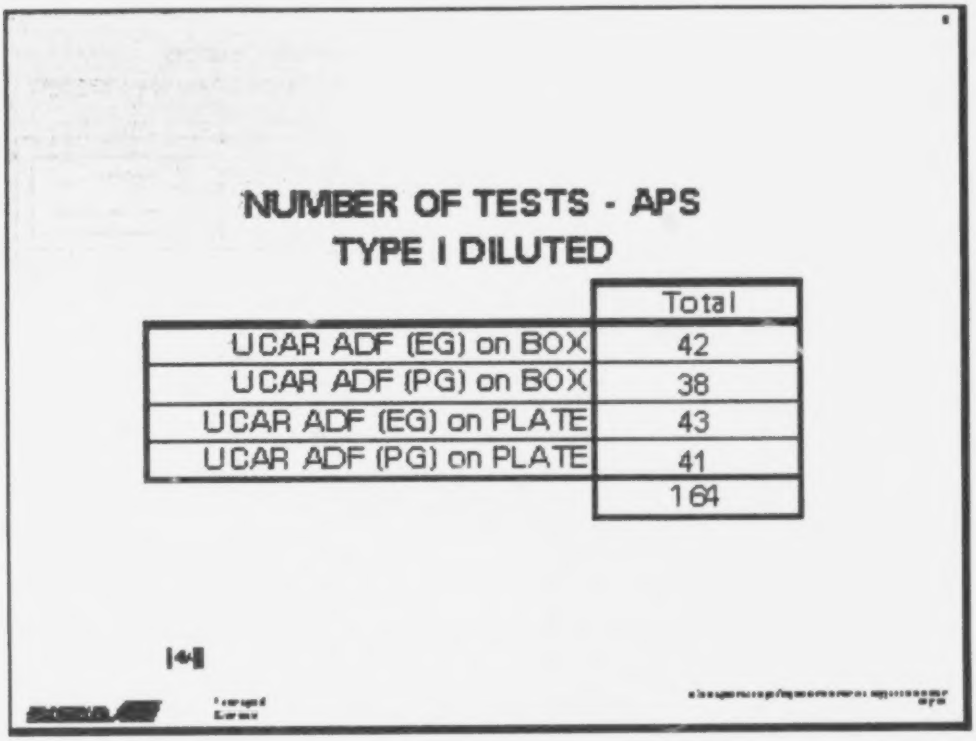
COLD-SOAK BOX



APS TEST PLAN FOR 2001-2002

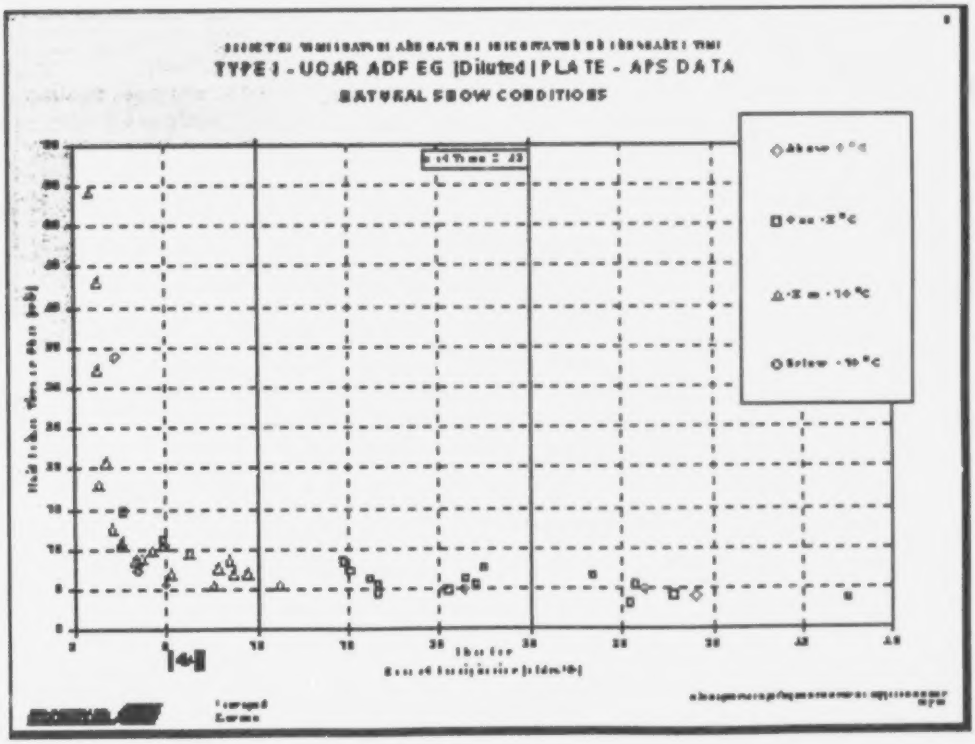
POS.	SURFACE TYPE	FLUID		Fluid Conc.	Fluid Type[1]
		AMOUNT (L)	TEMP (°C)		
1	RATE PAN				
2	Standard plate for ET test	1	20	10° Buffer	E
3	Standard plate for ET test	1	20	10° Buffer	P
4	7.5 cm box (empty)	0.5	60	10° Buffer	E
5	7.5 cm box (empty)	0.5	60	10° Buffer	P
~~6~~	~~7.5 cm box (empty)~~	~~0.5~~	~~60~~	~~50% mix~~	~~E or P~~

[1] E – Ethylene (Dow/UCAR EG ADF)
P – Propylene (Dow/UCAR PG ADF)



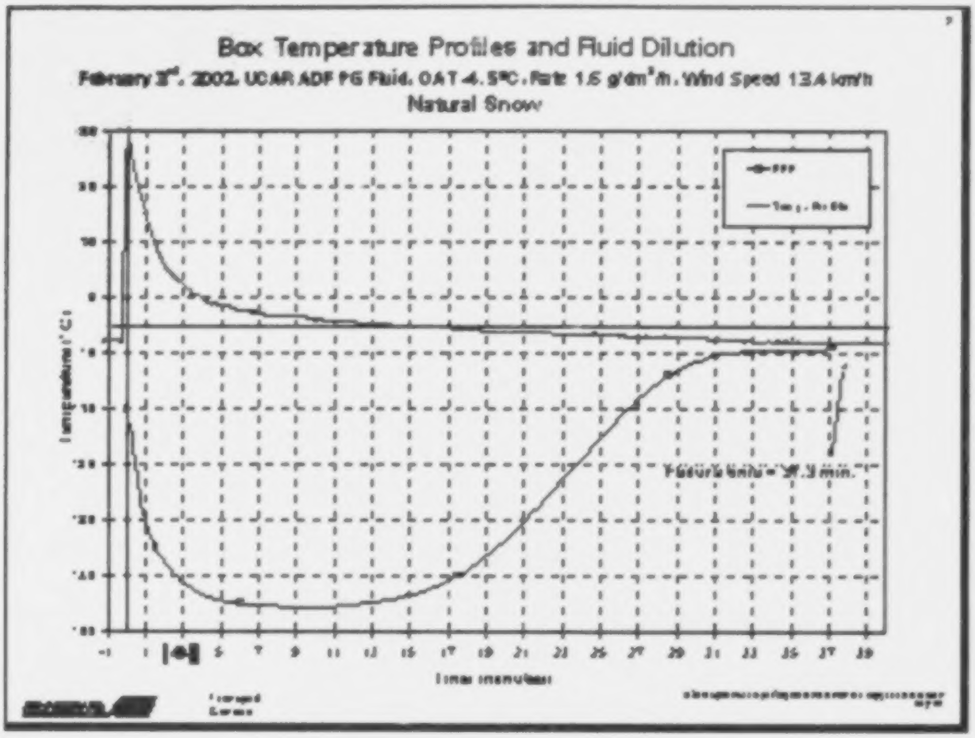
NUMBER OF TESTS - APS
TYPE I DILUTED

	Total
UCAR ADF (EG) on BOX	42
UCAR ADF (PG) on BOX	38
UCAR ADF (EG) on PLATE	43
UCAR ADF (PG) on PLATE	41
	164



TYPE I - UCAR ADF EG (Diluted) PLATE - APS DATA

NATURAL SNOW CONDITIONS


Box Temperature Profiles and Fluid Dilution
February 3rd, 2002. UCAR ADF PG Fluid. OAT -4.5°C. Rate 1.6 g/dm²/h. Wind Speed 13.4 km/h
Natural Snow
FFP
Temp. Profile
Failure time = 37.3 min.
Temperature (°C)
Time (minutes)
-1
1
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39

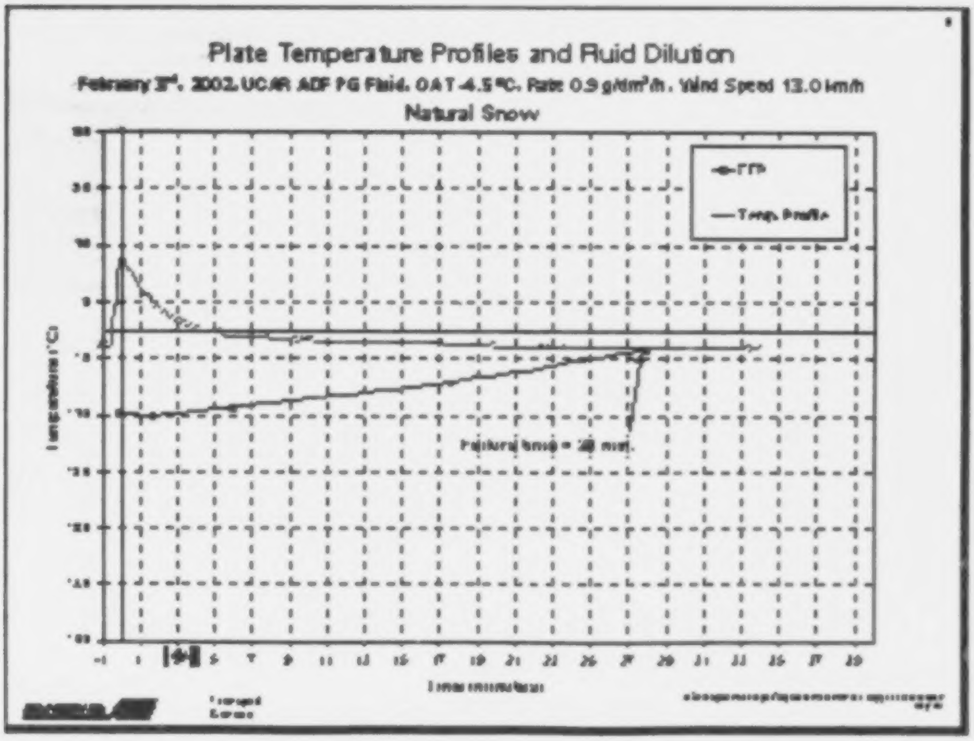
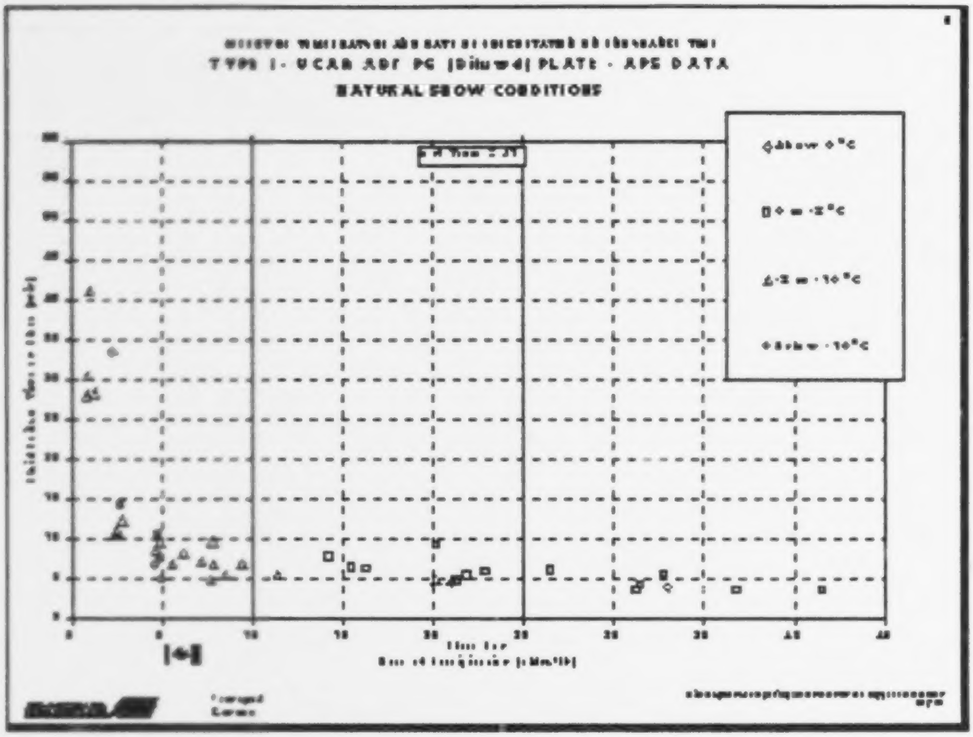
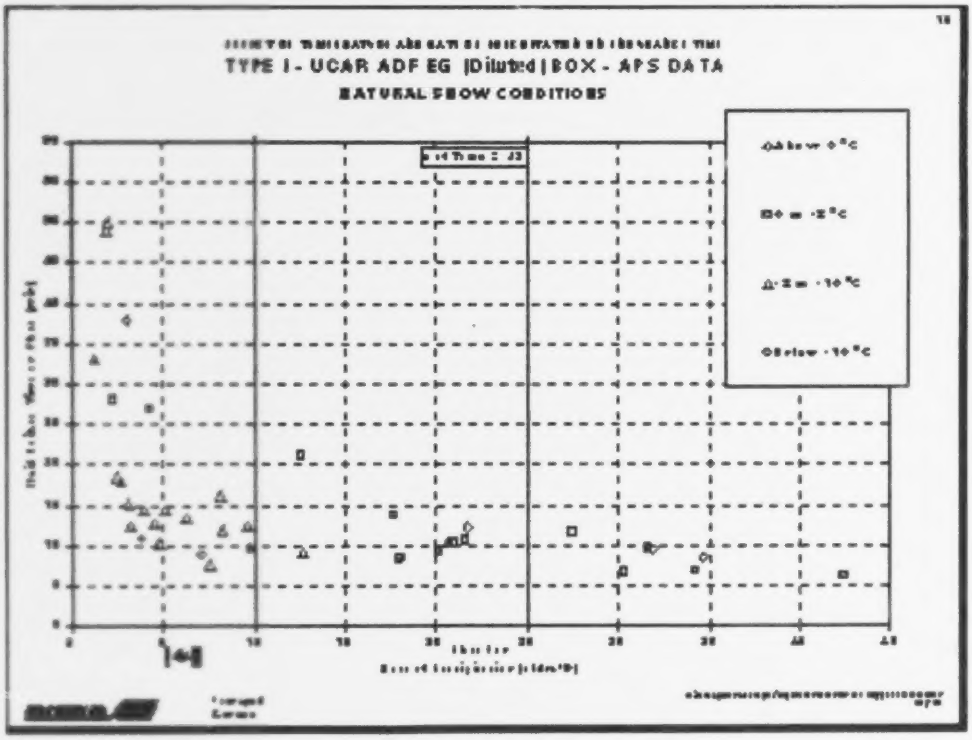
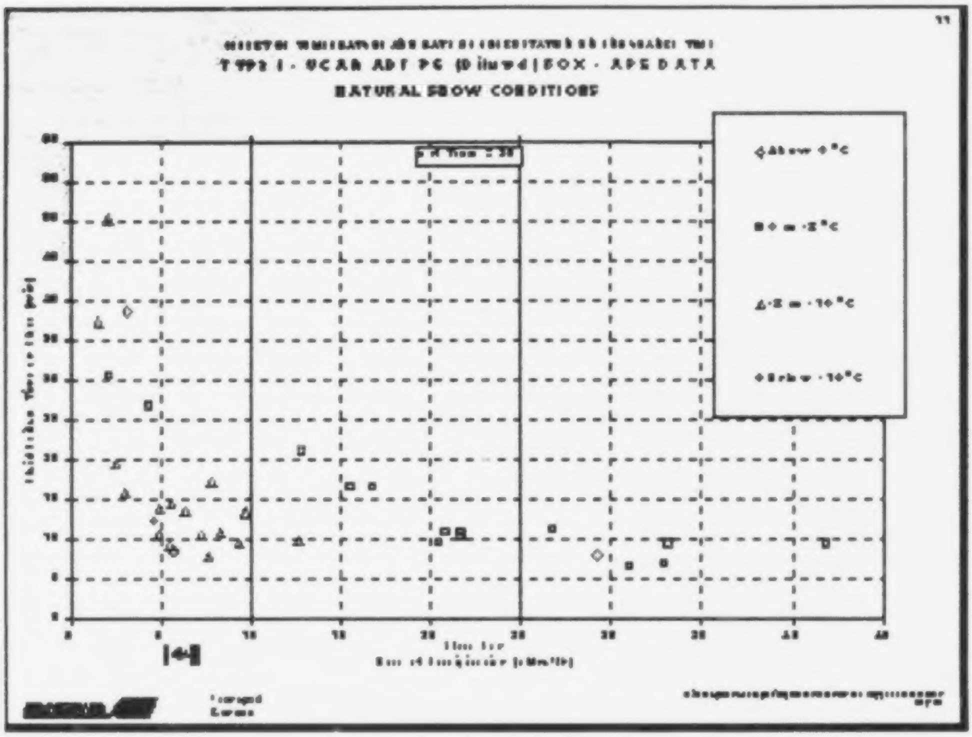
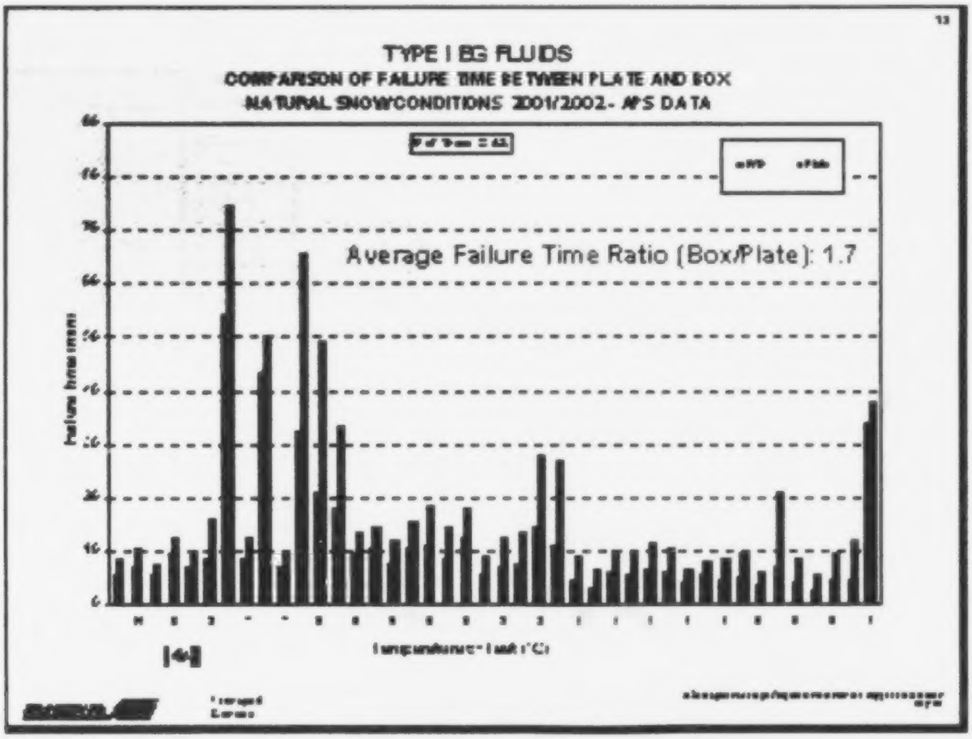


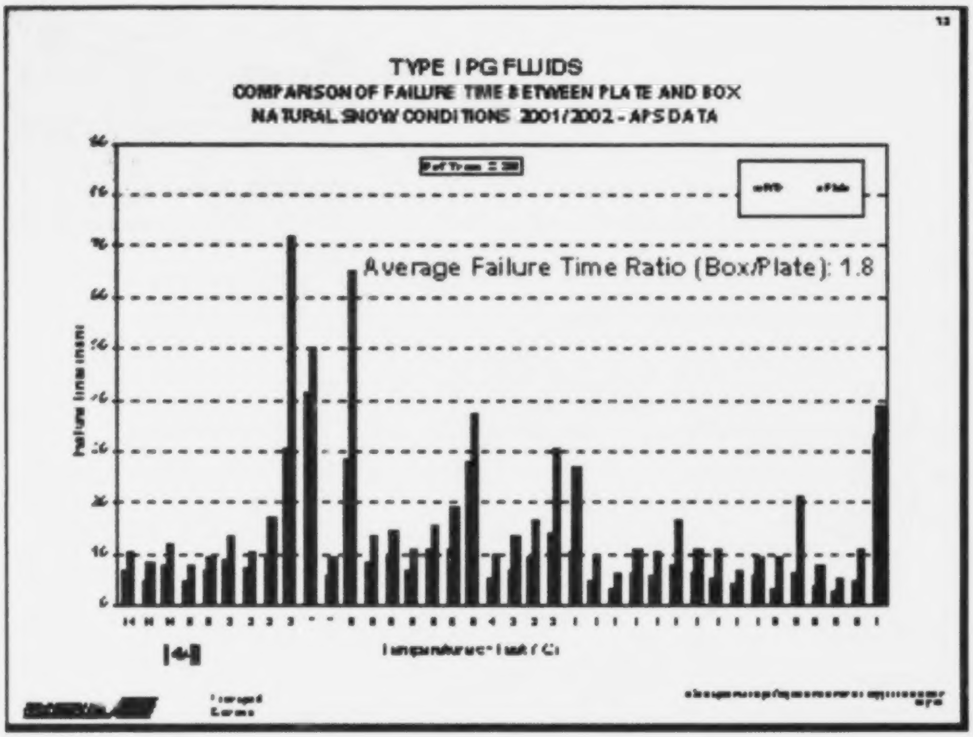
Plate Temperature Profiles and Fluid Dilution
February 3rd, 2002. UCAR ADF PG Fluid. OAT -4.5°C. Rate 0.9 g/dm²/h. Wind Speed 13.0 km/h
Natural Snow
FFP
Temp. Profile
Failure time = 28 min.
Temperature (°C)
Time (minutes)
-1
1
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39

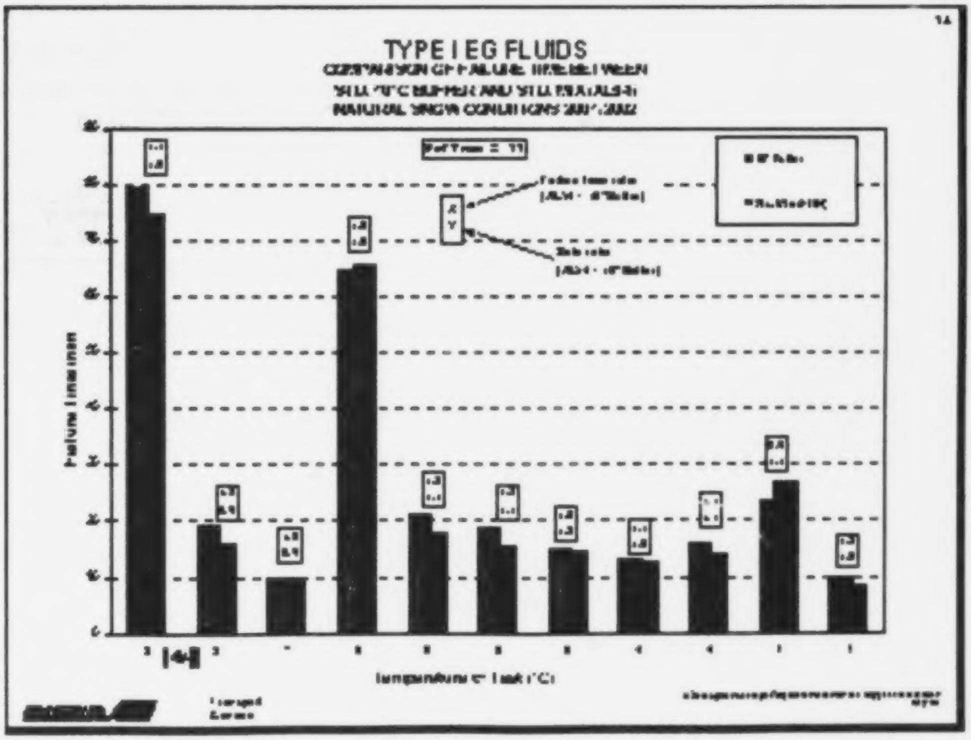

TYPE I - UCAR ADF PG (Diluted) PLATE - APS DATA
NATURAL SNOW CONDITIONS
Above 0°C
0 to -3°C
-3 to -10°C
Below -10°C

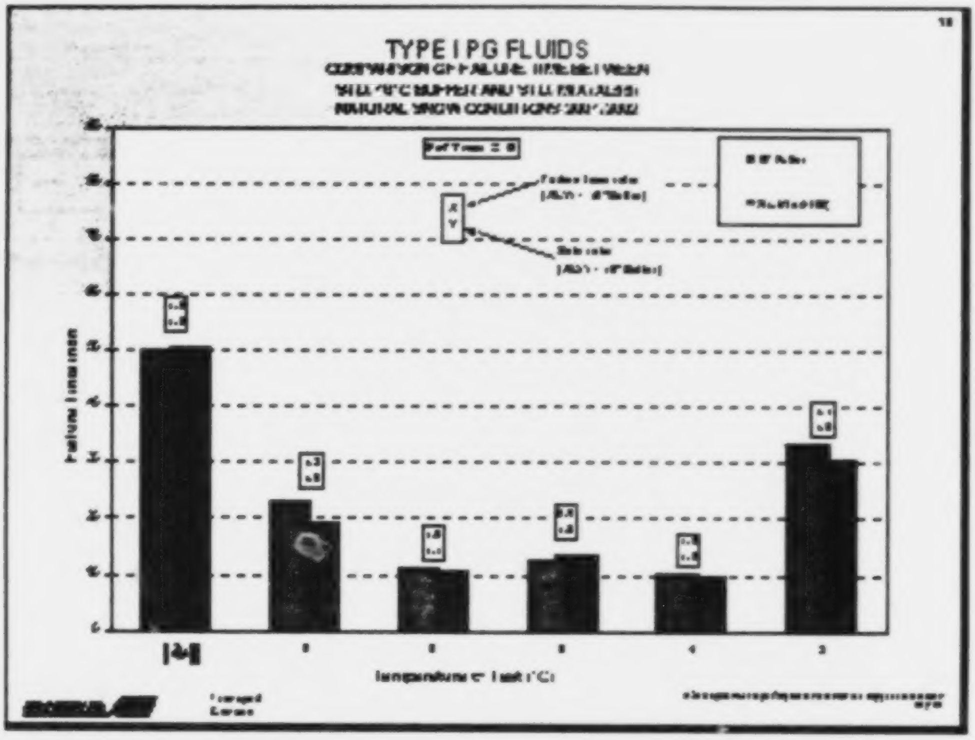

TYPE I - UCAR ADF EG (Diluted) BOX - APS DATA
NATURAL SNOW CONDITIONS
Above 0°C
0 to -3°C
-3 to -10°C
Below -10°C


11
TYPE I - UCAR ADF PG (Diluted) BOX - APS DATA
NATURAL SNOW CONDITIONS
Above 0°C
0 to -3°C
-3 to -10°C
Below -10°C


13
TYPE I EG FLUIDS
COMPARISON OF FAILURE TIME BETWEEN PLATE AND BOX
NATURAL SNOW CONDITIONS 2001/2002 - APS DATA
Average Failure Time Ratio (Box/Plate): 1.7


13
TYPE I PG FLUIDS
COMPARISON OF FAILURE TIME BETWEEN PLATE AND BOX
NATURAL SNOW CONDITIONS 2001/2002 - APS DATA
Average Failure Time Ratio (Box/Plate): 1.8
Failure time (min)
Temperature (°C)


14
TYPE I EG FLUIDS
COMPARISON OF FAILURE TIME BETWEEN
Failure time (min)
Temperature (°C)

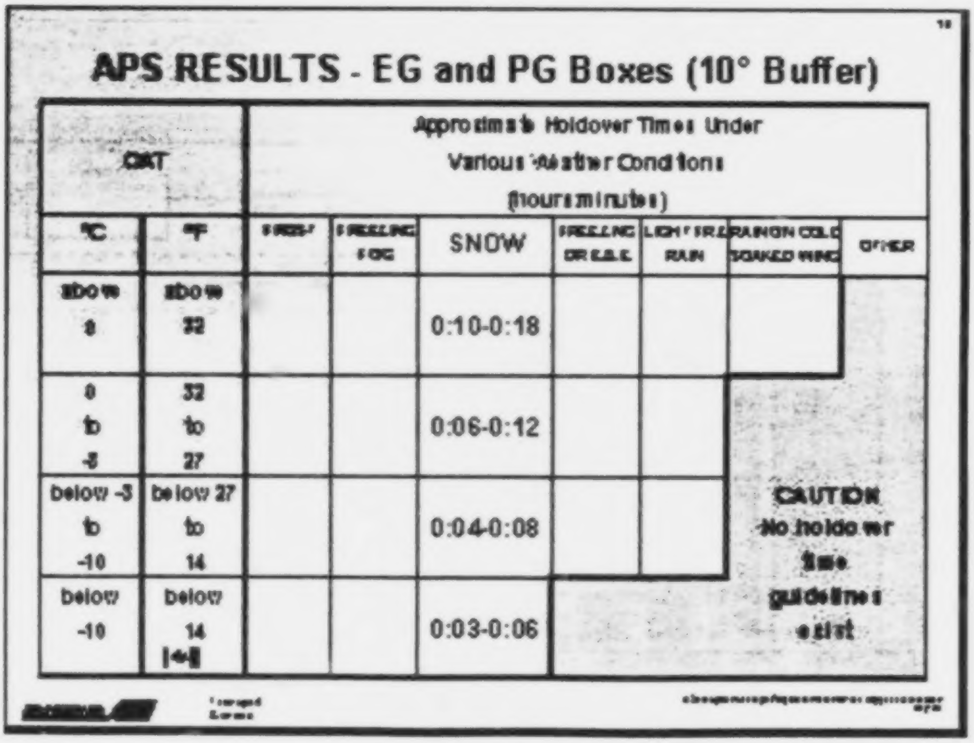


TYPE I PG FLUIDS

COMPARISON OF FAILURE TIMES BETWEEN

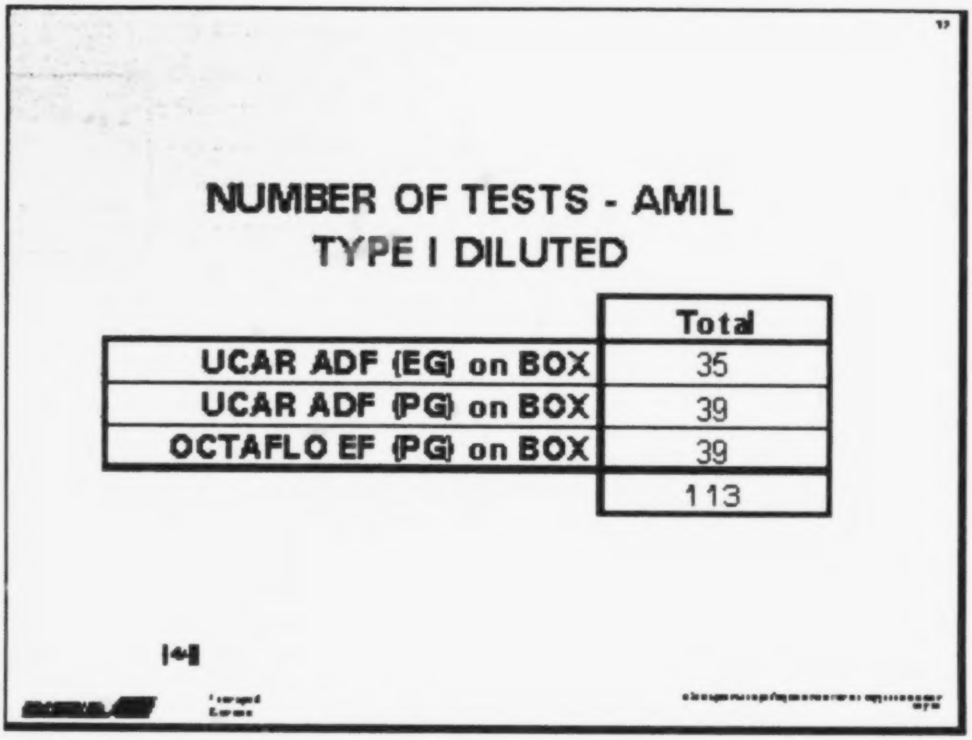
[illegible]

NATURAL SNOW CONDITIONS [illegible]



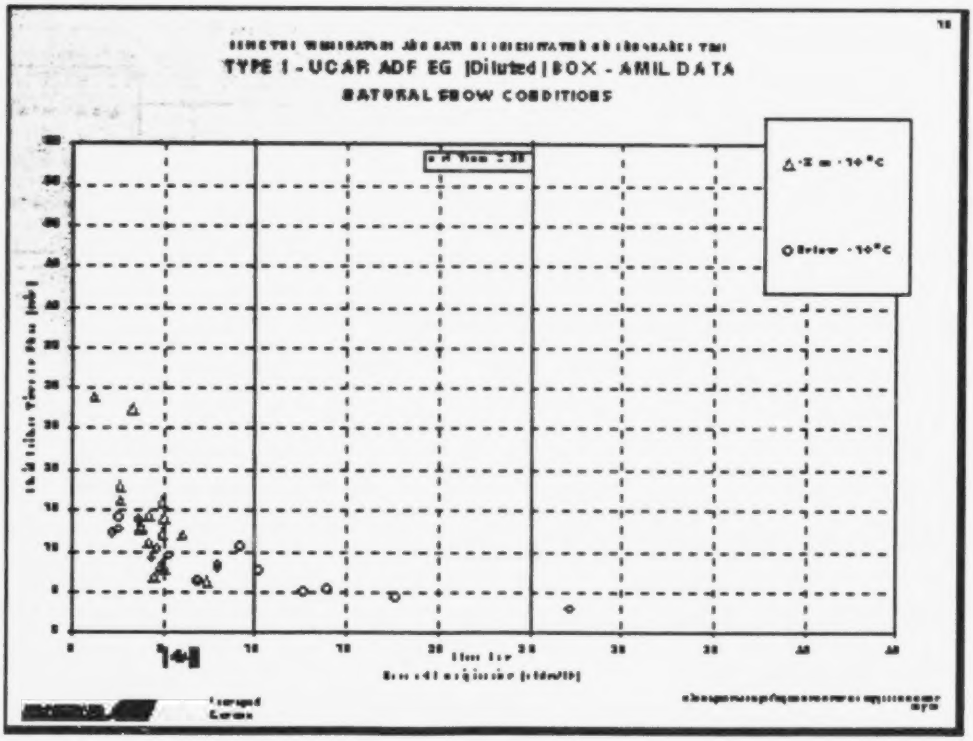
APS RESULTS - EG and PG Boxes (10° Buffer)

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			0:10-0:18				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			0:06-0:12				
below -3 to -10	below 27 to 14			0:04-0:08				
below -10	below 14			0:03-0:06				



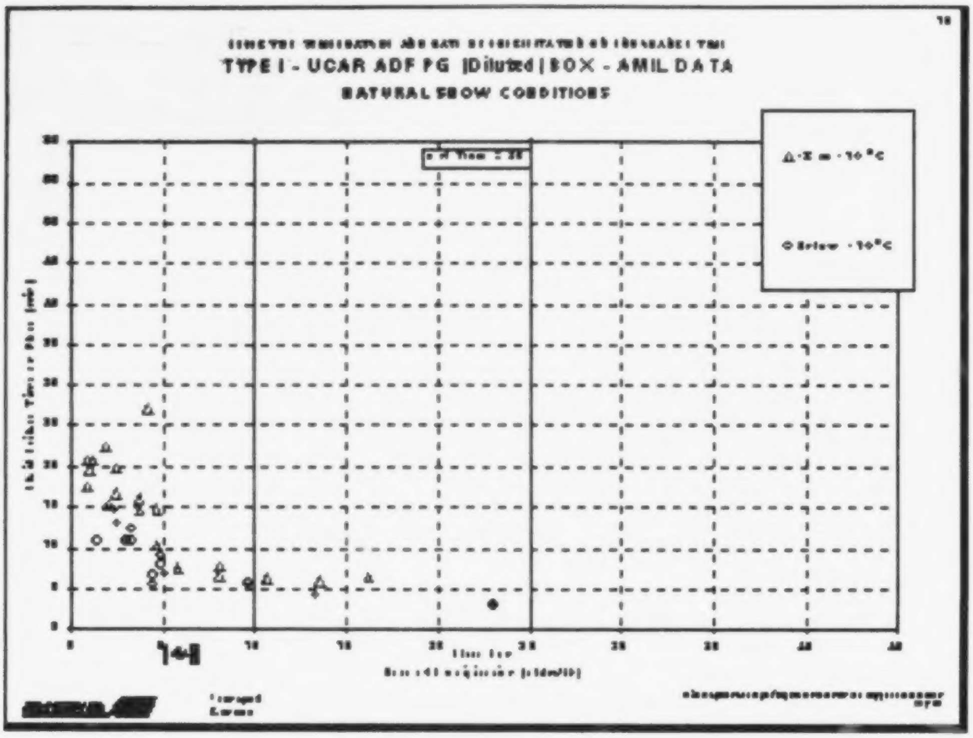
NUMBER OF TESTS - AMIL TYPE I DILUTED

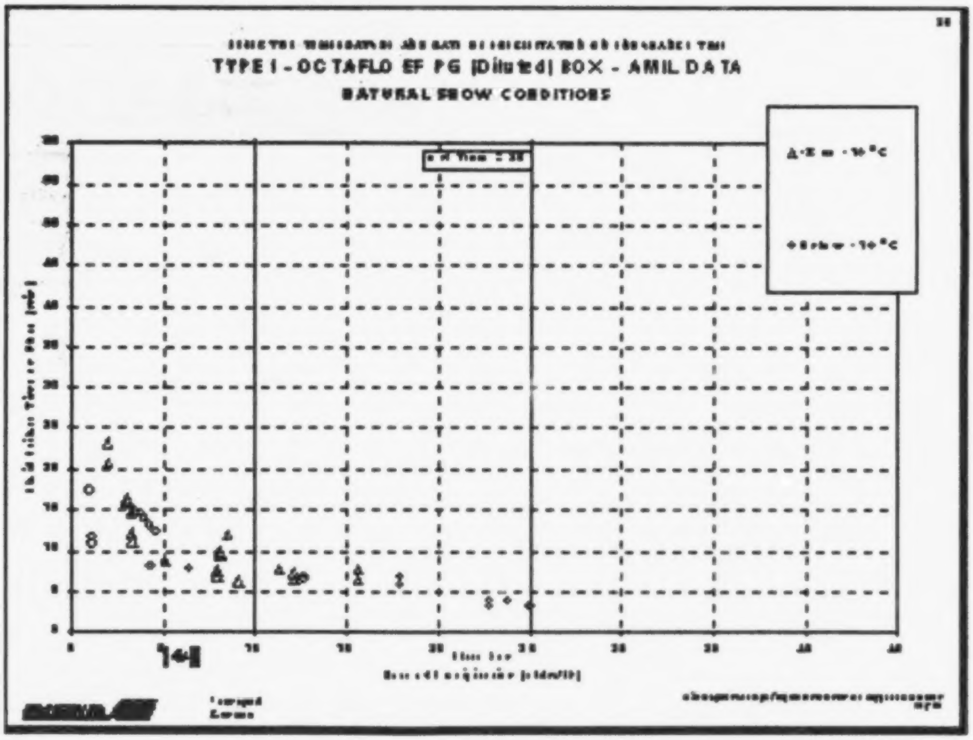
	Total
UCAR ADF (EG) on BOX	35
UCAR ADF (PG) on BOX	39
OCTAFLO EF (PG) on BOX	39
	113

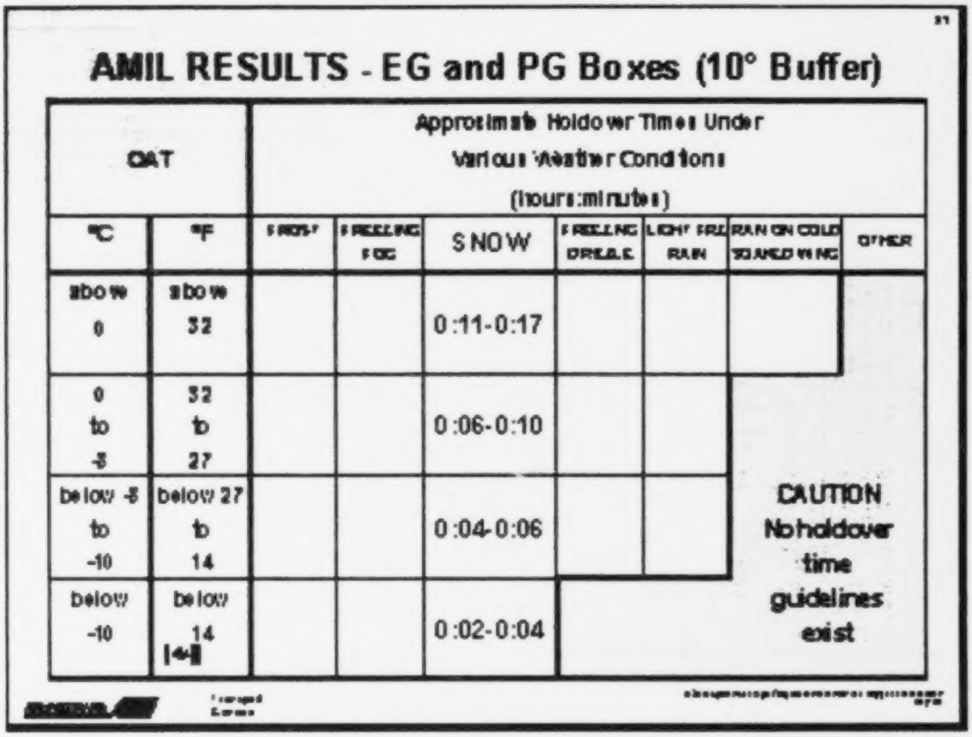


TYPE I - UCAR ADF EG (Diluted) BOX - AMIL DATA

NATURAL SNOW CONDITIONS


TYPE I - UCAR ADF PG (Diluted) BOX - AMIL DATA
NATURAL SNOW CONDITIONS


TYPE I - OCTAFLO EF PG (Diluted) BOX - AMIL DATA
NATURAL SNOW CONDITIONS



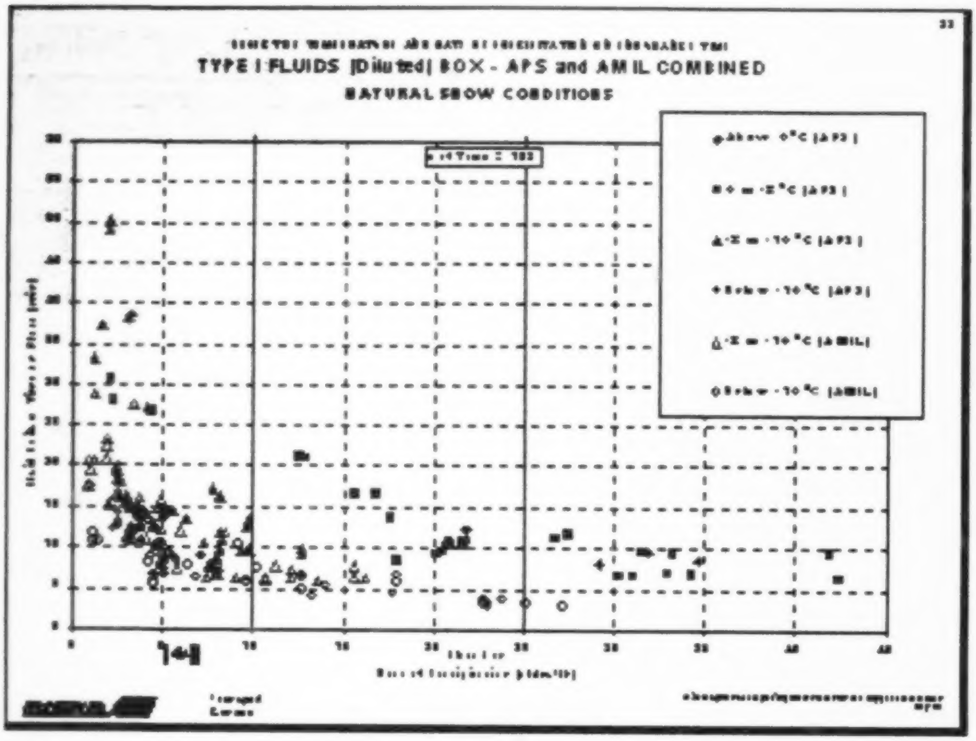
31

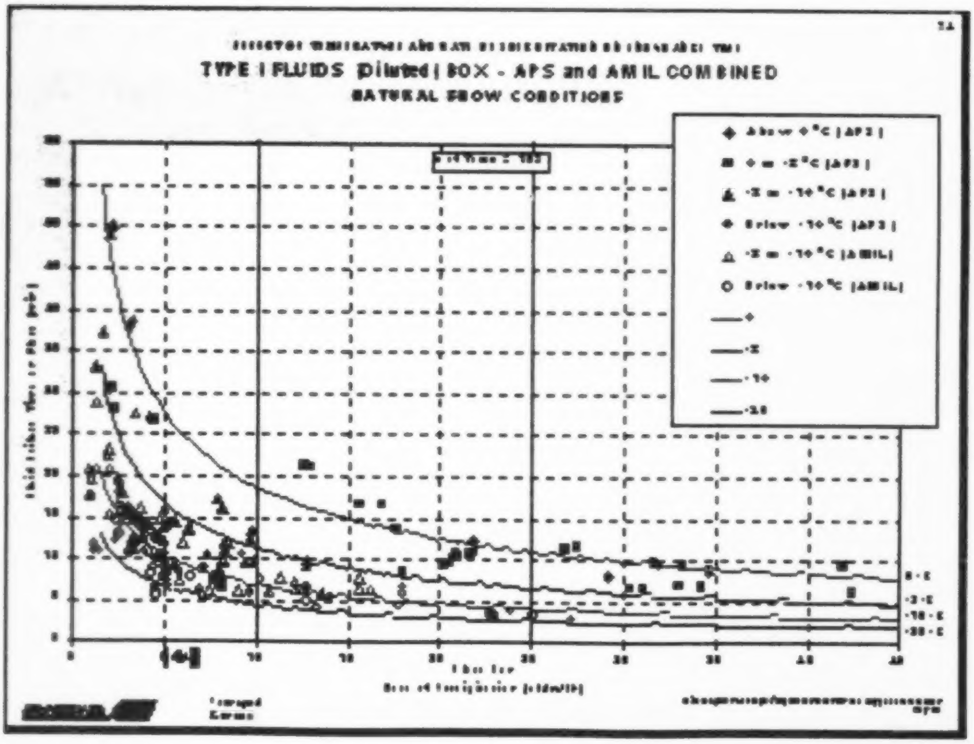
AMIL RESULTS - EG and PG Boxes (10° Buffer)

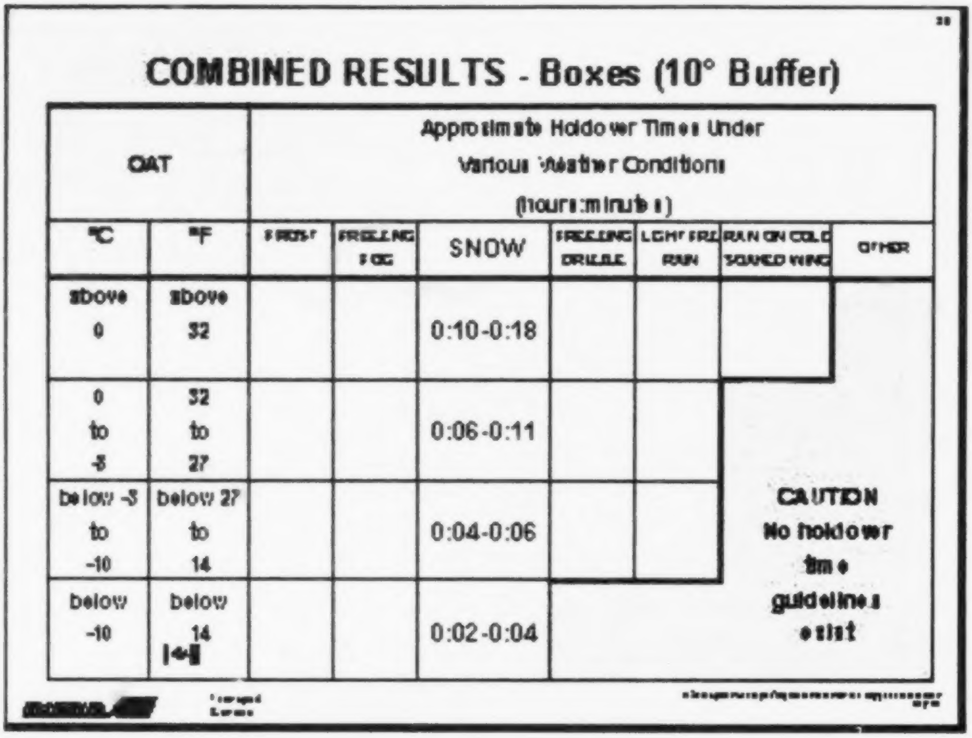
OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			0:11-0:17				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			0:06-0:10				
below -3 to -10	below 27 to 14			0:04-0:06				
below -10	below 14			0:02-0:04				

32

COMBINED RESULTS

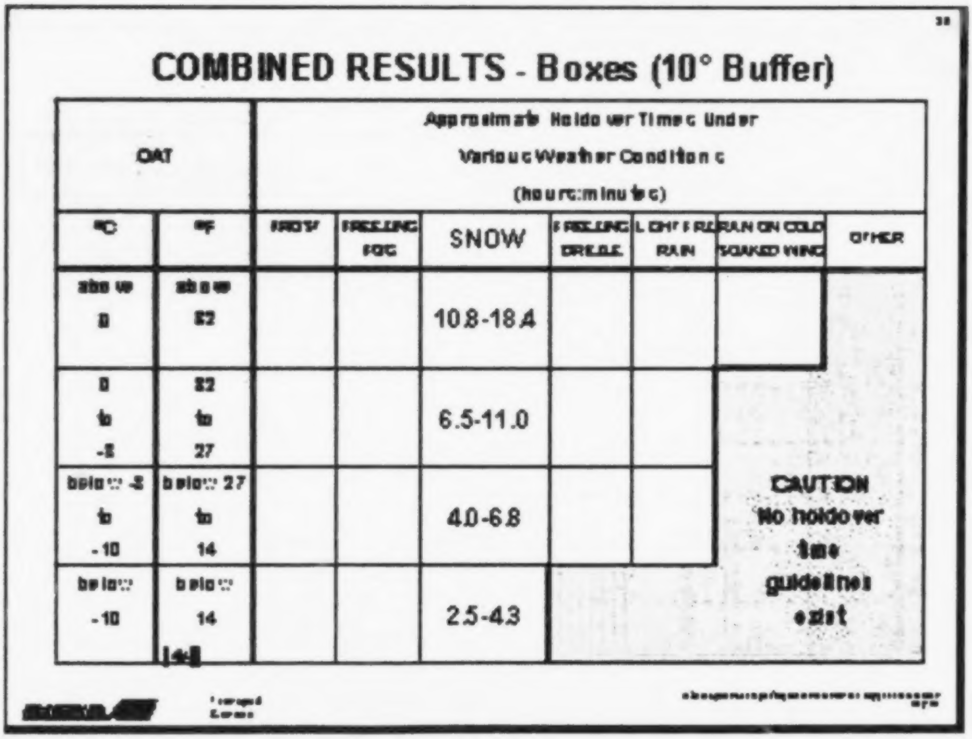

33
TYPE I FLUIDS (Diluted) BOX - APS and AMIL COMBINED
NATURAL SNOW CONDITIONS
Above 0°C (APS)
0 to -3°C (APS)
-3 to -10°C (APS)
Below -10°C (APS)
-3 to -10°C (AMIL)
Below -10°C (AMIL)
0
10
15
20
25
30
35
40
45


34
TYPE I FLUIDS (Diluted) BOX - APS and AMIL COMBINED
NATURAL SNOW CONDITIONS
Above 0°C (APS)
0 to -3°C (APS)
-3 to -10°C (APS)
Below -10°C (APS)
-3 to -10°C (AMIL)
Below -10°C (AMIL)
0
-3
-10
-25
0
10
15
20
25
30
35
40
45



COMBINED RESULTS - Boxes (10° Buffer)

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			0:10-0:18				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			0:06-0:11				
below -3 to -10	below 27 to 14			0:04-0:06				
below -10	below 14			0:02-0:04				

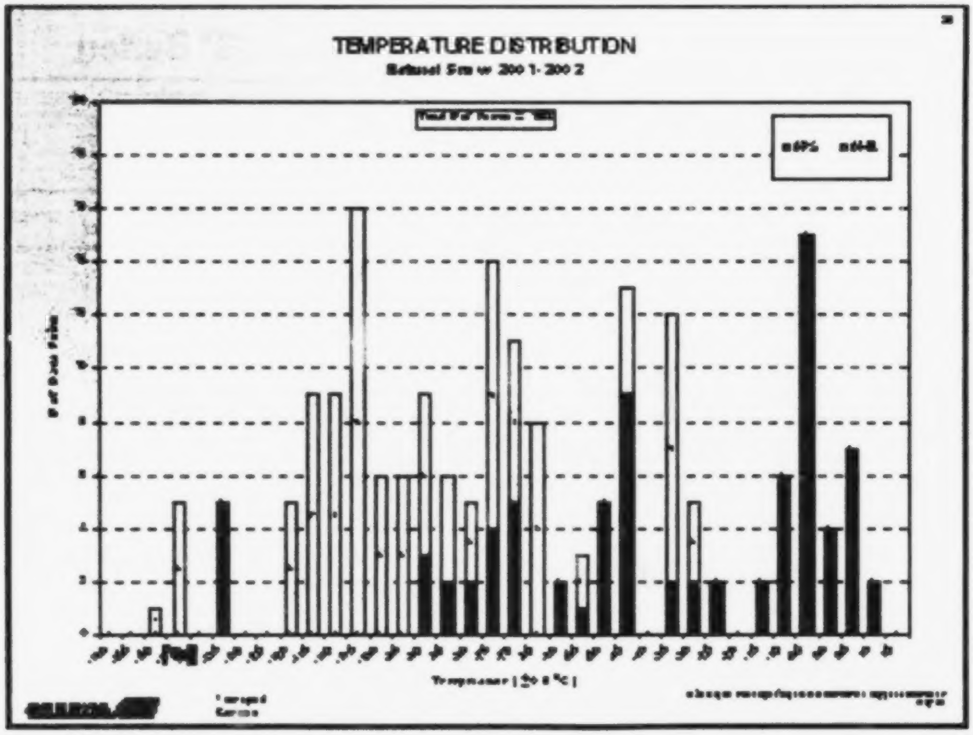


COMBINED RESULTS - Boxes (10° Buffer)

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			10.8-18.4				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			6.5-11.0				
below -3 to -10	below 27 to 14			4.0-6.8				
below -10	below 14			2.5-4.3				

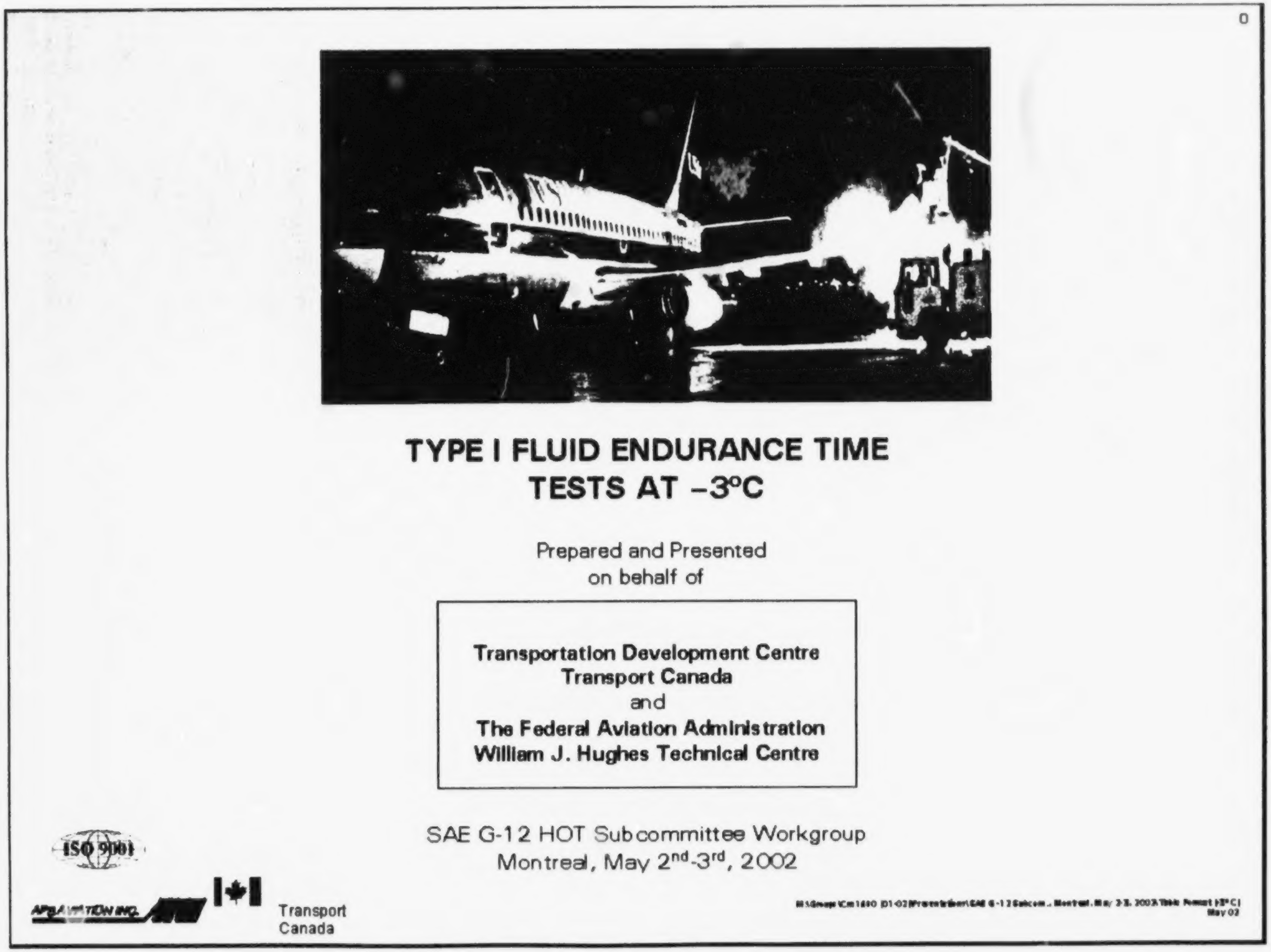
SUMMARY OF RESULTS - Boxes (10° Buffer)

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)			
°C	°F	TOULOUSE	APS	AMIL	APS+AMIL
above 0	above 32	0:07-0:12	0:10-0:18	0:11-0:17	0:10-0:18
0 to -3	32 to 27	-	0:06-0:12	0:06-0:10	0:06-0:11
below -3 to -10	below 27 to 14	0:03-0:06	0:04-0:08	0:04-0:06	0:04-0:06
below -10	below 14	0:02-0:04	0:03-0:06	0:02-0:04	0:02-0:04



TEMPERATURE DISTRIBUTION

Season 2001-2002



0

TYPE I FLUID ENDURANCE TIME TESTS AT –3°C

Prepared and Presented
on behalf of

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
William J. Hughes Technical Centre

SAE G-12 HOT Subcommittee Workgroup
Montreal, May 2nd-3rd, 2002

ISO 9001
APS AVIATION INC.
Transport
Canada

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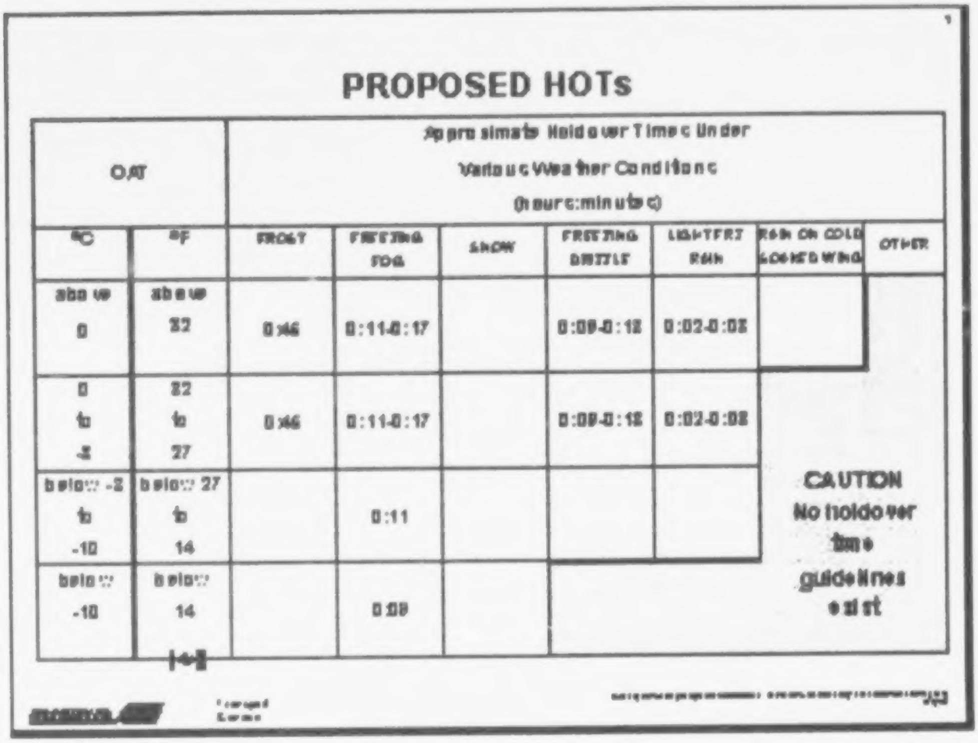
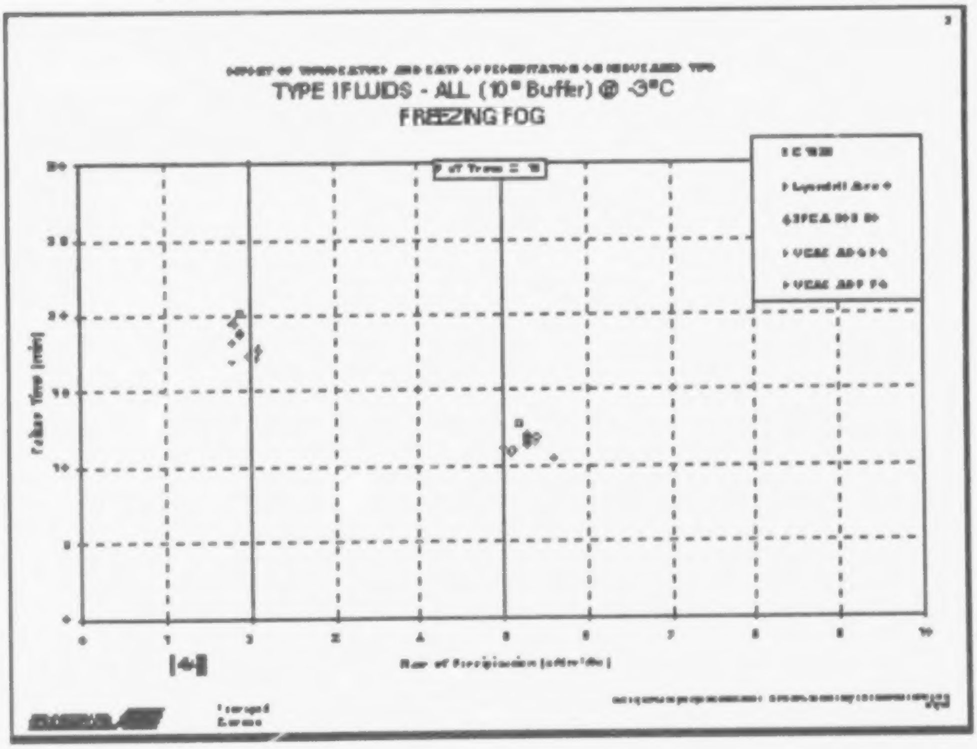


1

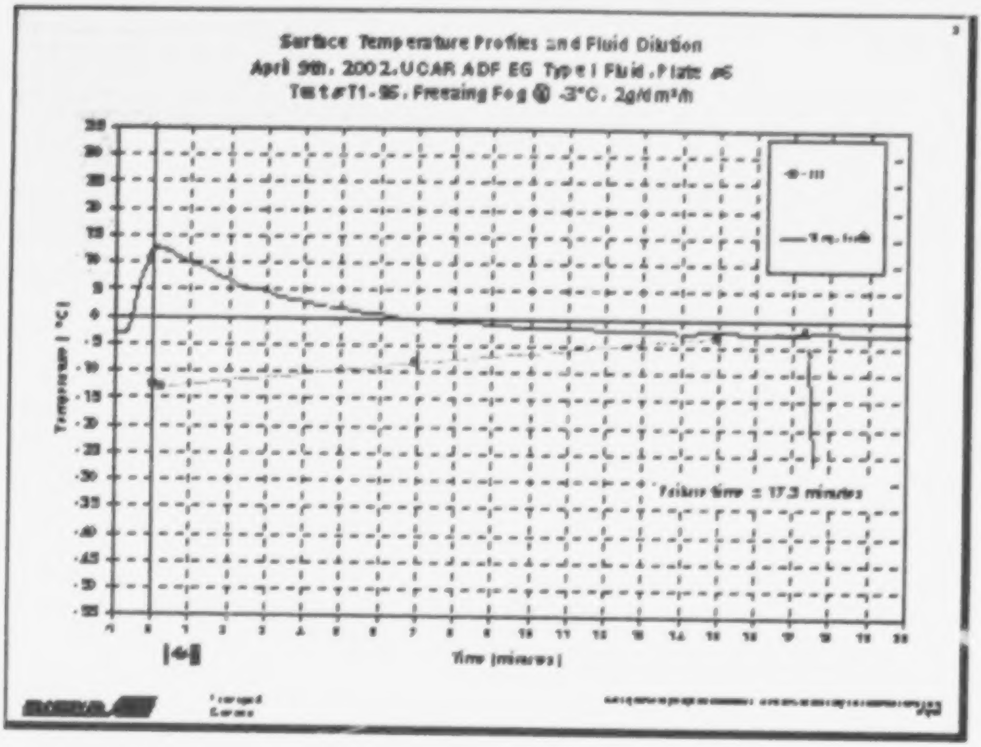
PROPOSED HOTs

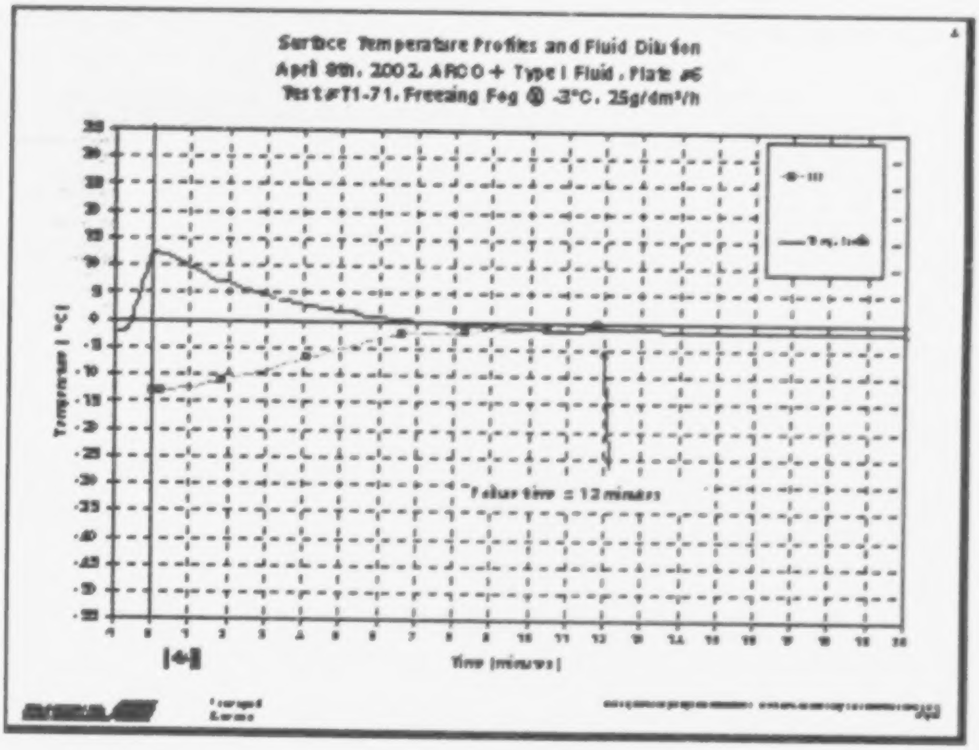
OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32	0:46	0:11-0:17		0:09-0:13	0:02-0:05		
0 to -3	32 to 27	0:46	0:11-0:17		0:09-0:13	0:02-0:05		
below -3 to -10	below 27 to 14		0:11				CAUTION No holdover time guidelines exist	
below -10	below 14		0:09					

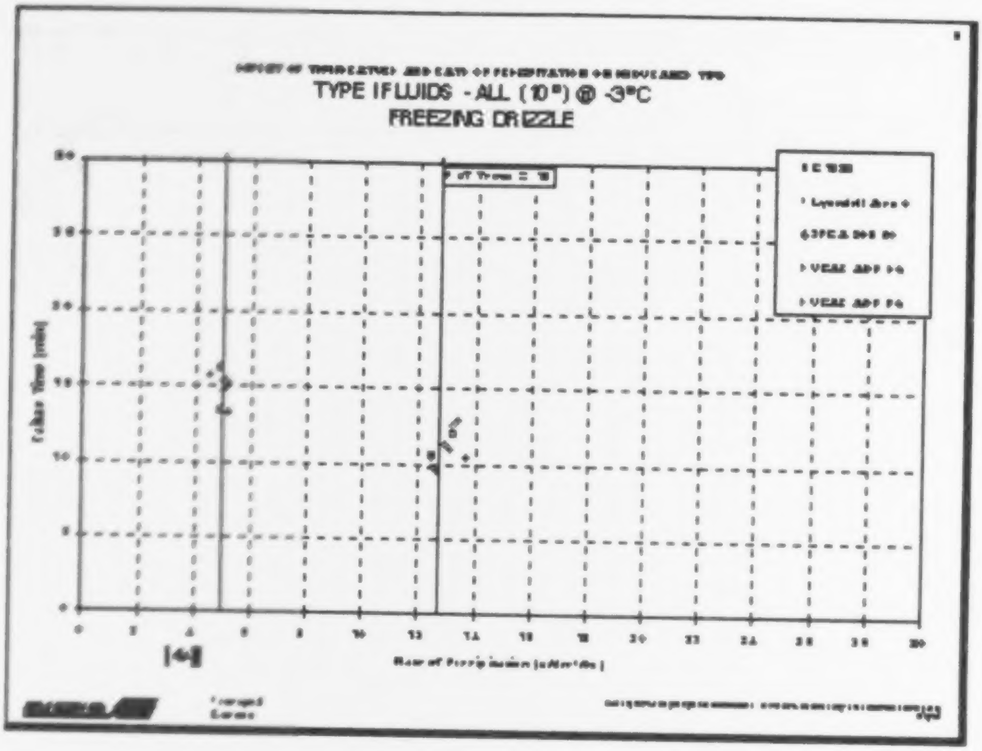


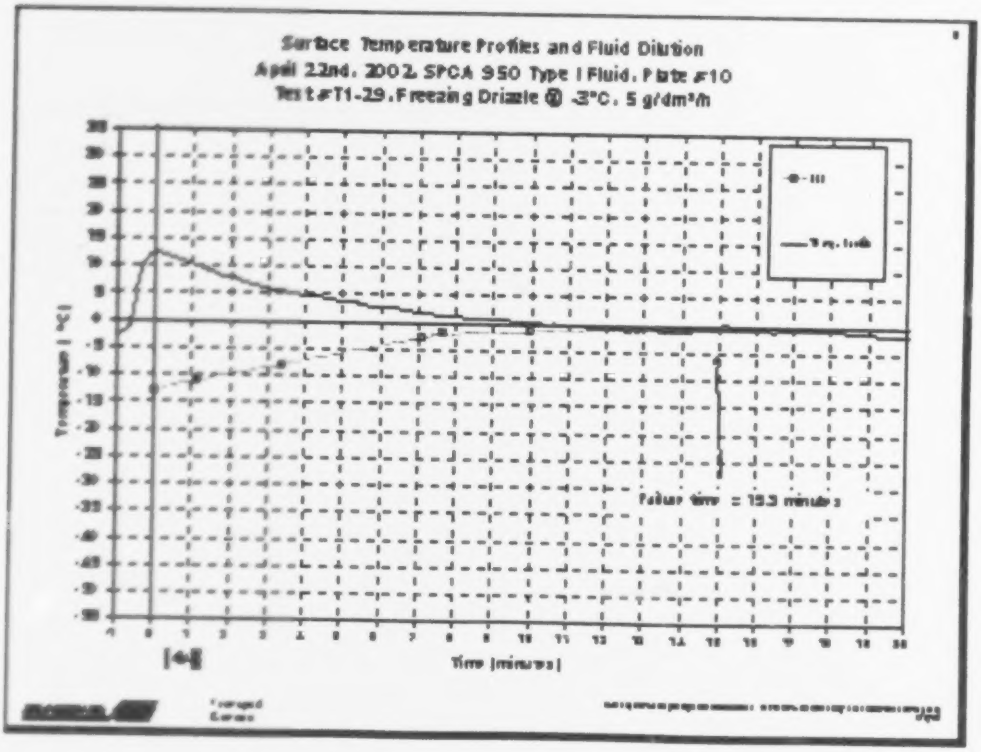
2

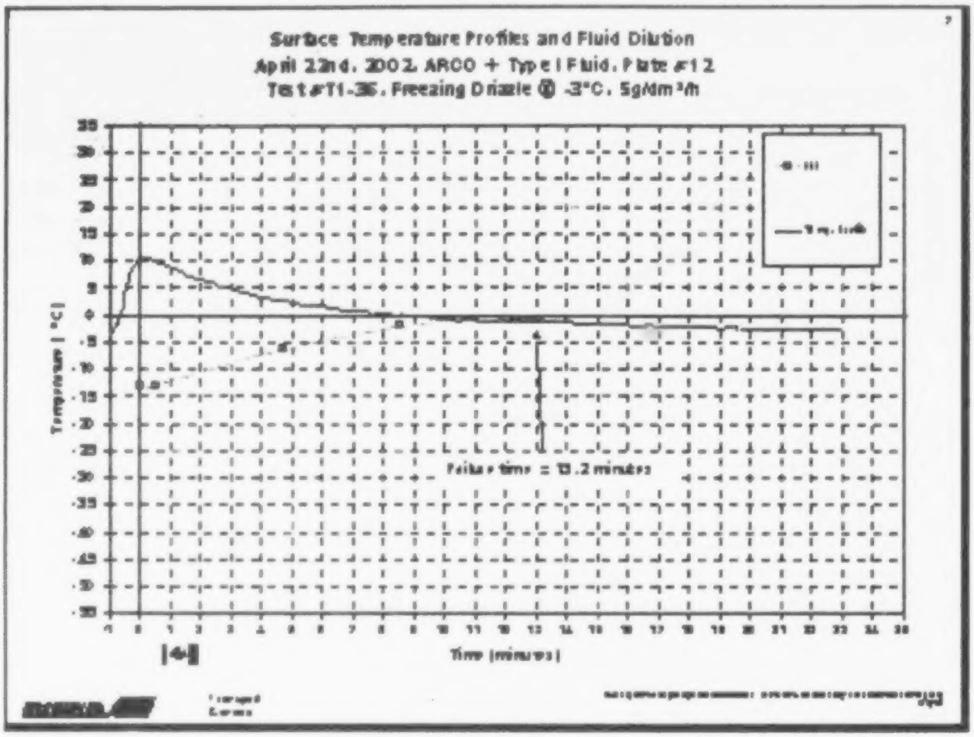
TYPE I FLUIDS - ALL (10° Buffer) @ -3°C
FREEZING FOG

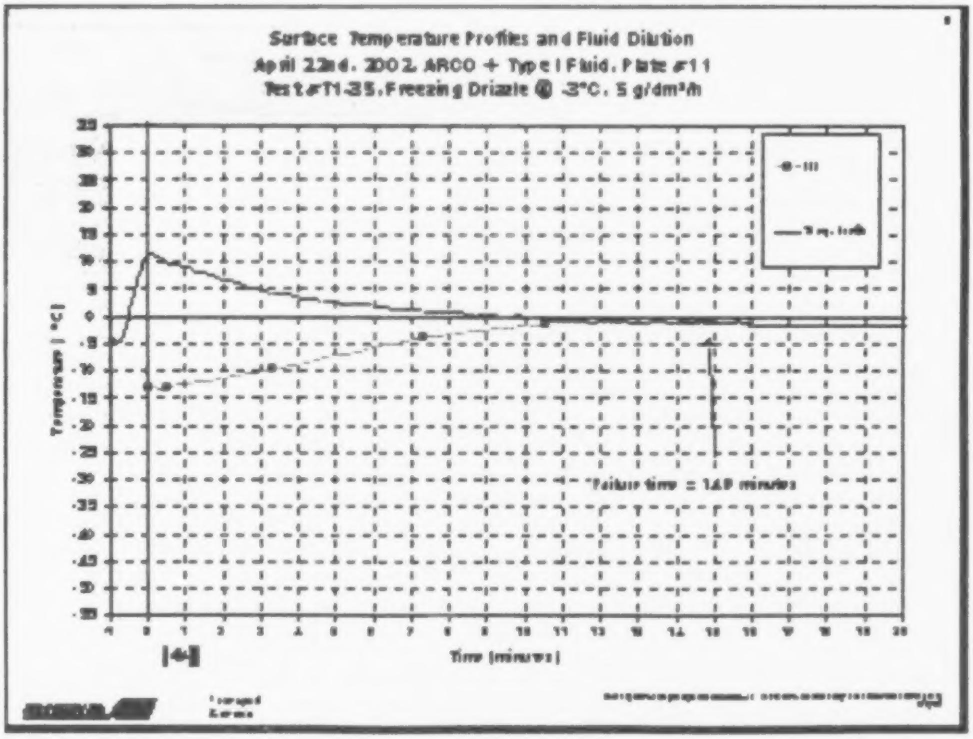

Surface Temperature Profiles and Fluid Dilution
April 9th, 2002, UCAR ADF EG Type I Fluid, Plate #6
Test #T1-95, Freezing Fog @ -3°C, 2g/dm²/h
Temperature (°C)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
Failure time = 17.3 minutes
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Time (minutes)

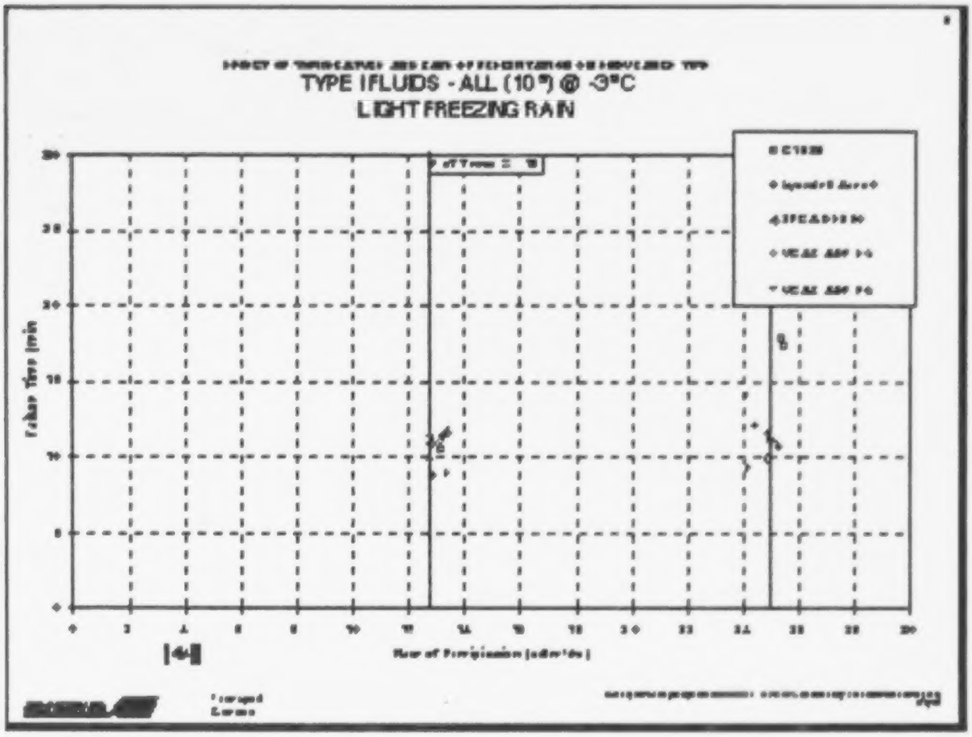

Surface Temperature Profiles and Fluid Dilution
April 9th, 2002, ARCO+ Type I Fluid, Plate #6
Test #T1-71, Freezing Fog @ -3°C, 25g/dm²/h
Temperature (°C)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
Failure time = 12 minutes
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Time (minutes)

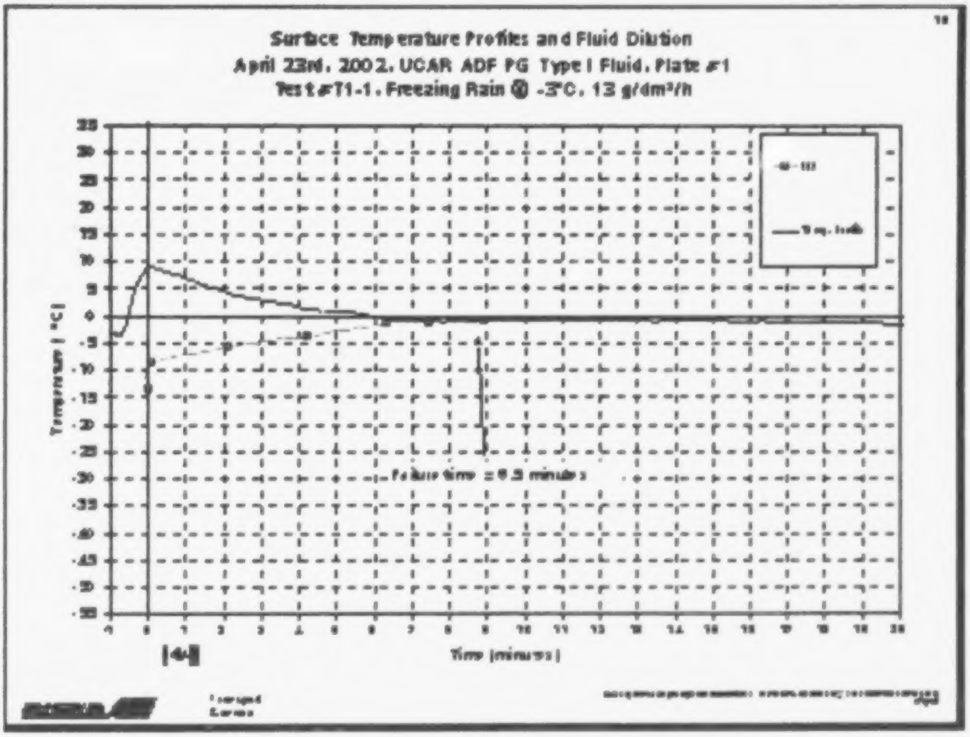

TYPE I FLUIDS - ALL (10°) @ -3°C
FREEZING DRIZZLE
Failure Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Rate of Precipitation (g/dm²/h)

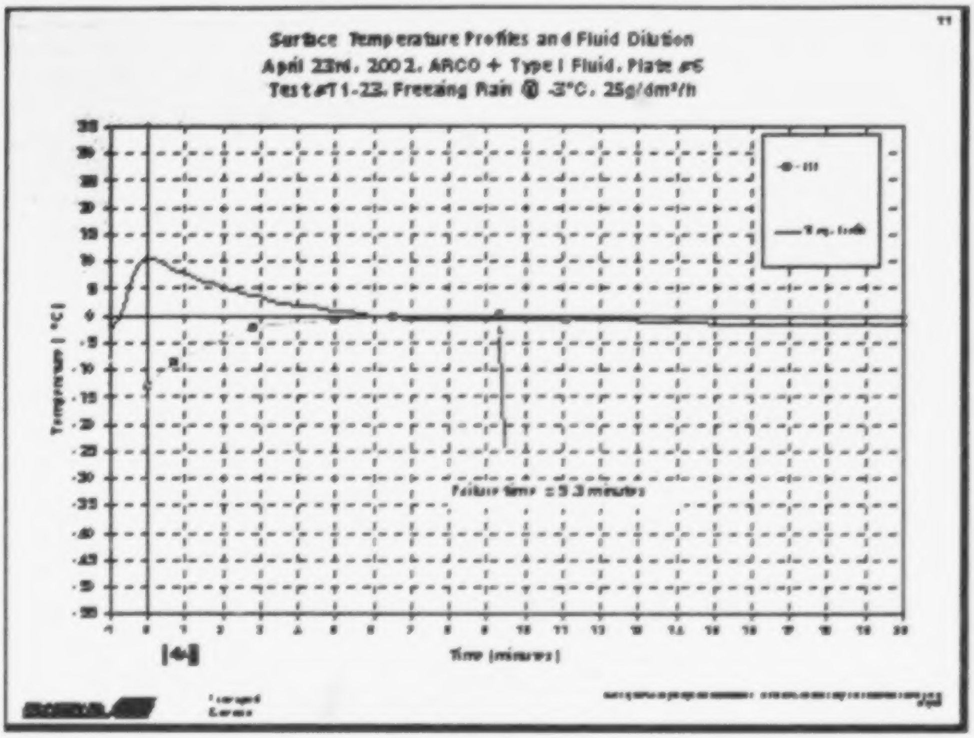

Surface Temperature Profiles and Fluid Dilution
April 22nd, 2002, SPCA 950 Type I Fluid, Plate #10
Test #T1-29, Freezing Drizzle @ -3°C, 5 g/dm²/h
Temperature (°C)
Time (minutes)
Failure time = 15.3 minutes


Surface Temperature Profiles and Fluid Dilution
April 22nd, 2002, ARCO + Type I Fluid, Plate #12
Test #T1-36, Freezing Drizzle @ -3°C, 5g/dm²/h
Temperature (°C)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
Failure time = 13.2 minutes
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
Time (minutes)

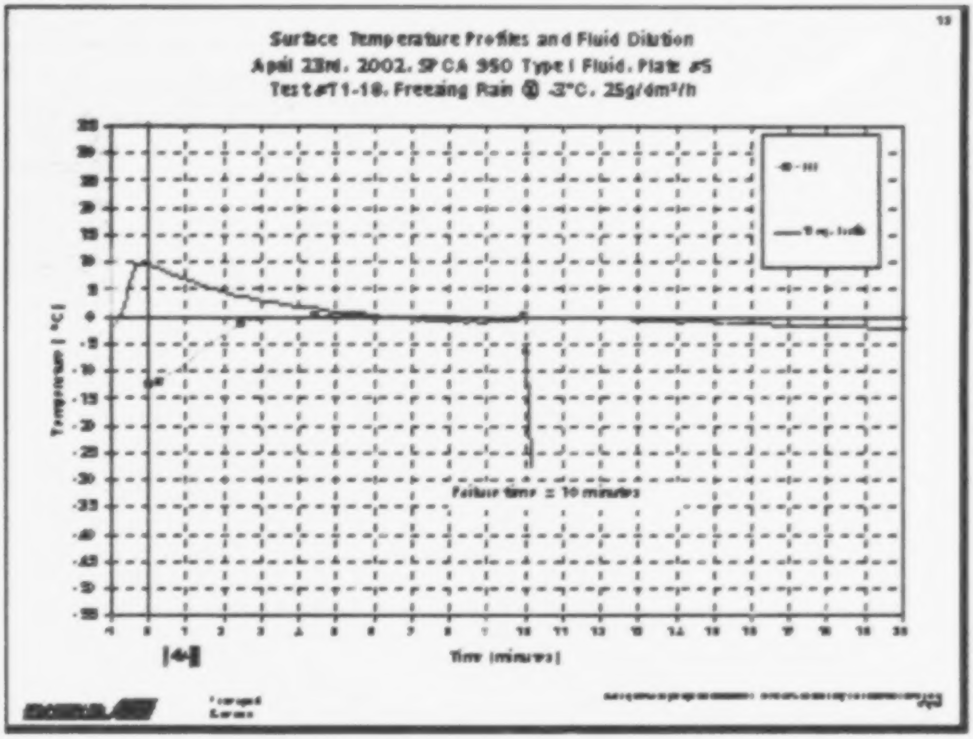

Surface Temperature Profiles and Fluid Dilution
April 22nd, 2002, ARCO + Type I Fluid, Plate #11
Test #T1-35, Freezing Drizzle @ -3°C, 5 g/dm²/h
Temperature (°C)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
Failure time = 14.9 minutes
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Time (minutes)


TYPE I FLUIDS - ALL (10°) @ -3°C
LIGHT FREEZING RAIN
Failure Time (min)
Rate of Precipitation (g/dm²/h)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

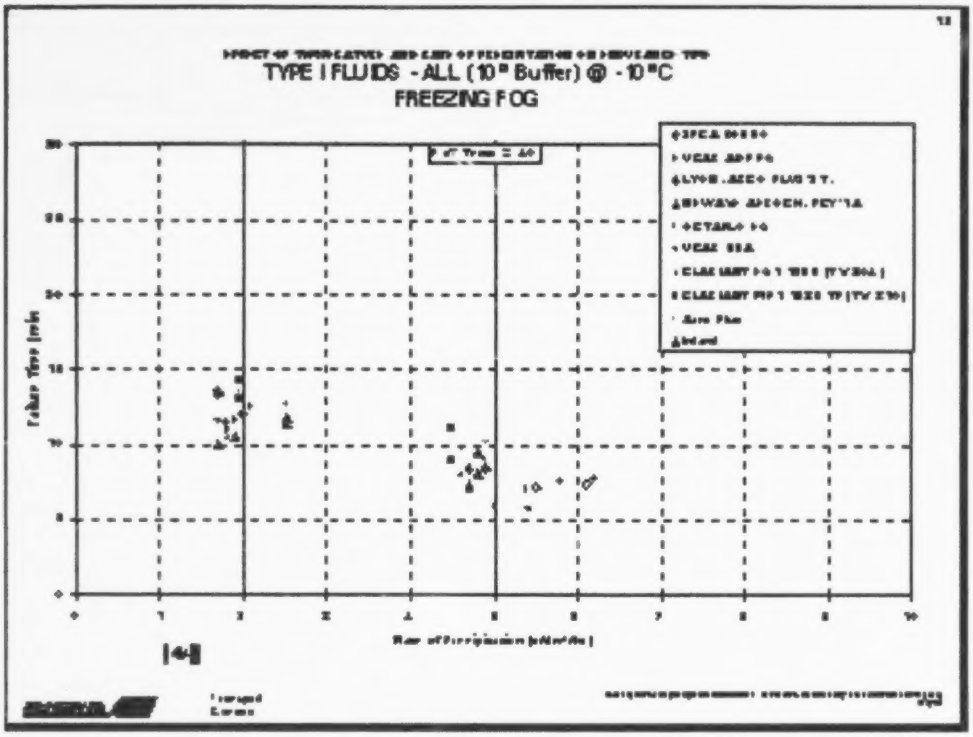

Surface Temperature Profiles and Fluid Dilution
April 23rd, 2002, UCAR ADF PG Type I Fluid, Plate #1
Test #T1-1, Freezing Rain @ -3°C, 13 g/dm²/h
Temperature (°C)
Time (minutes)
Failure time = 9.3 minutes
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

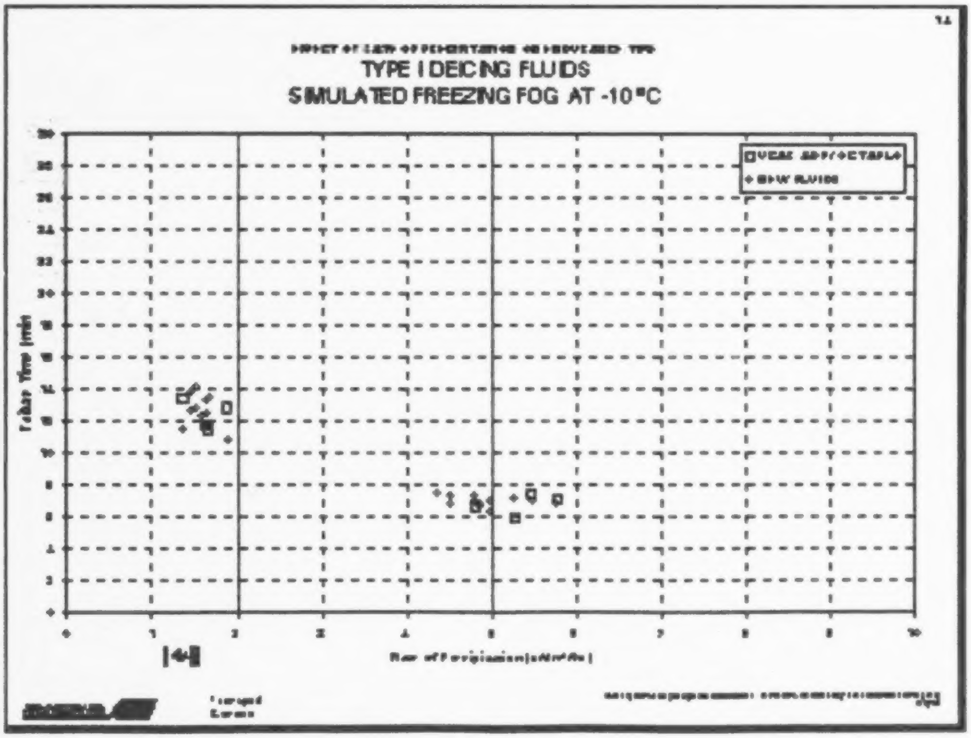


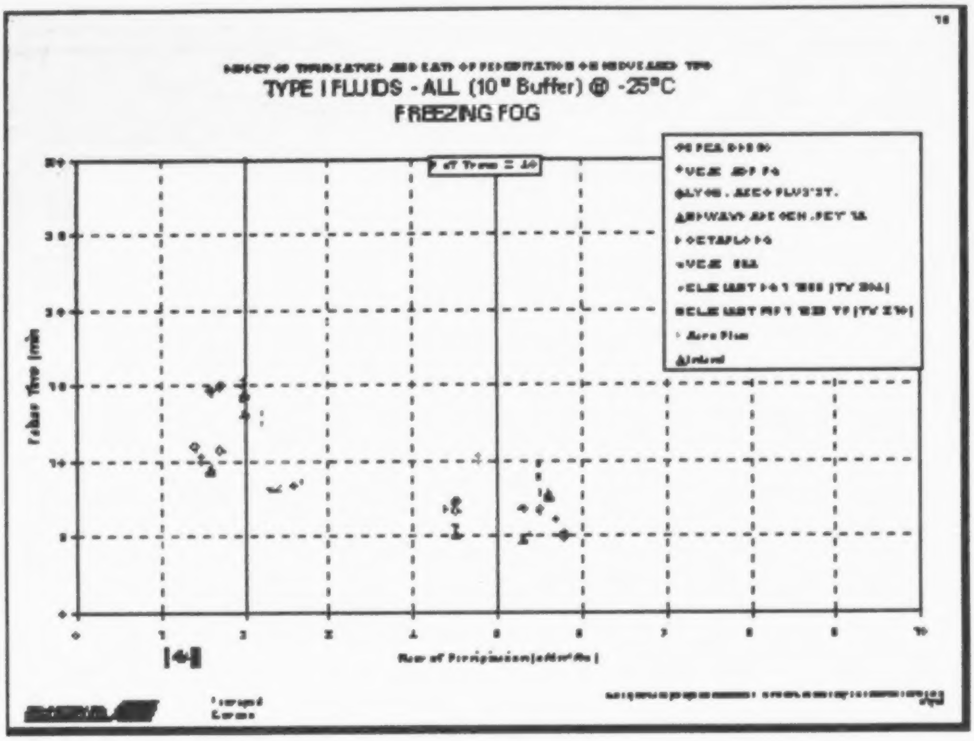
Surface Temperature Profiles and Fluid Dilution
April 23rd, 2002, ARCO + Type I Fluid, Plate #6
Test #T1-23, Freezing Rain @ -3°C, 25g/dm²/h

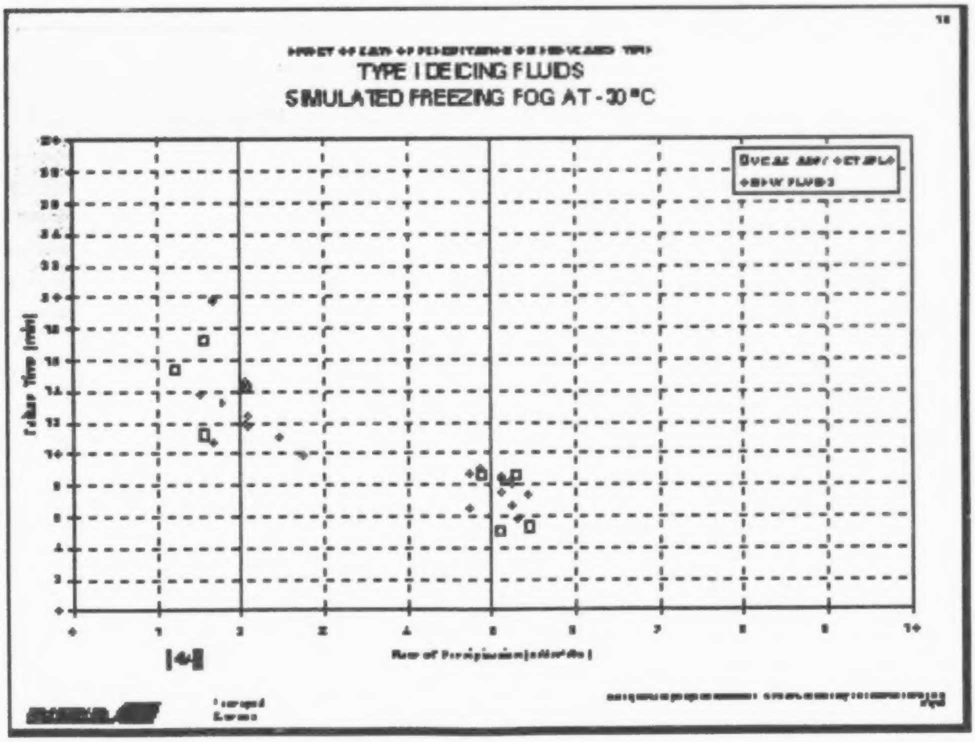


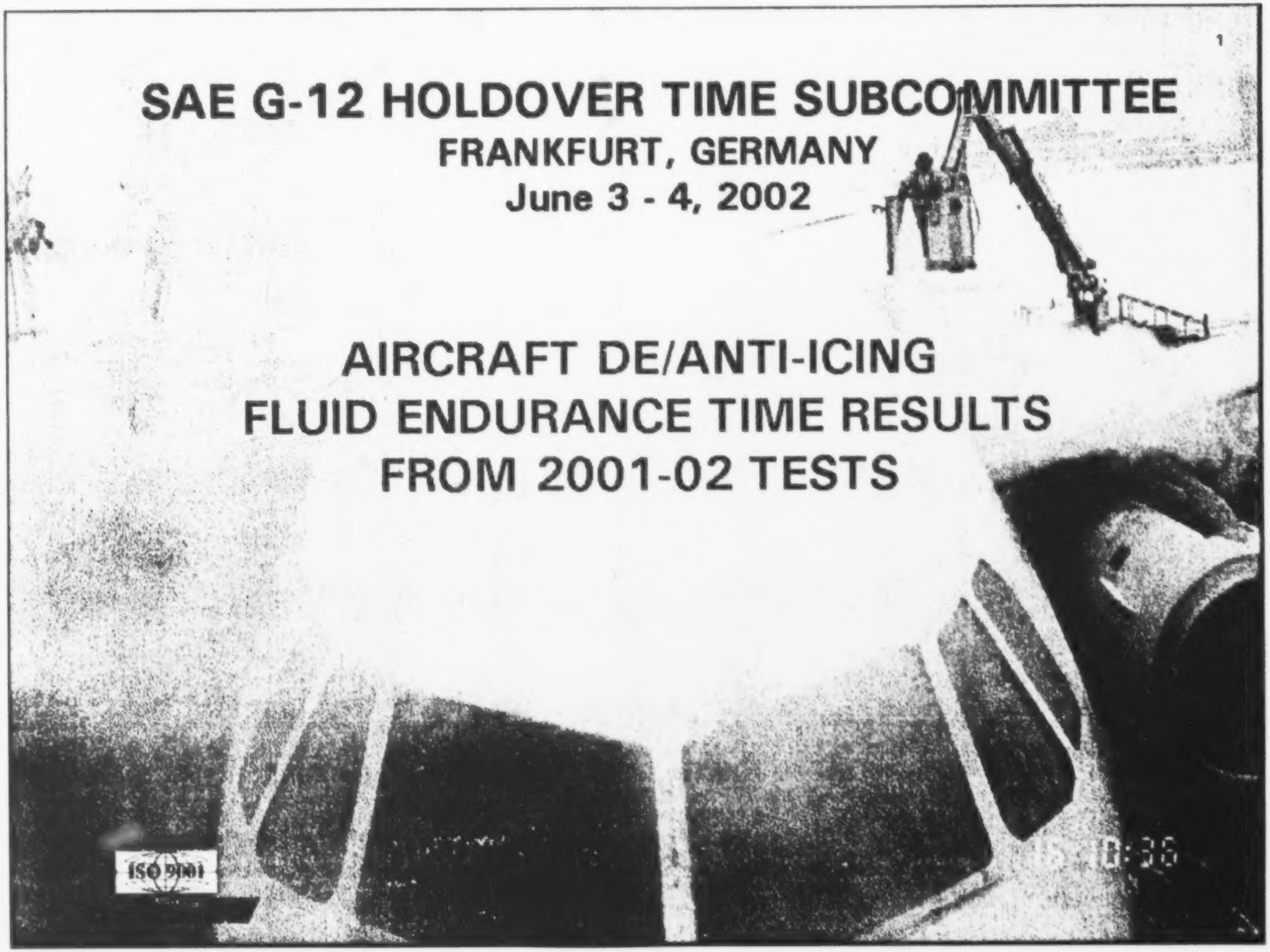
Surface Temperature Profiles and Fluid Dilution
April 23rd, 2002, SPCA 350 Type I Fluid, Plate #5
Test #T1-18, Freezing Rain @ -3°C, 25g/dm²/h


TYPE I FLUIDS - ALL (10° Buffer) @ -10°C
FREEZING FOG
0
1
2
3
4
5
6
7
8
9
10


TYPE I DEICING FLUIDS
SIMULATED FREEZING FOG AT -10°C
0
1
2
3
4
5
6
7
8
9
10


TYPE I FLUIDS - ALL (10" Buffer) @ -25°C
FREEZING FOG
Failure Time (min)
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
Aero Flex
Allied


TYPE I DEICING FLUIDS
SIMULATED FREEZING FOG AT -30°C
Failure Time (min)
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30



1

SAE G-12 HOLDOVER TIME SUBCOMMITTEE

FRANKFURT, GERMANY
June 3 - 4, 2002

AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FROM 2001-02 TESTS

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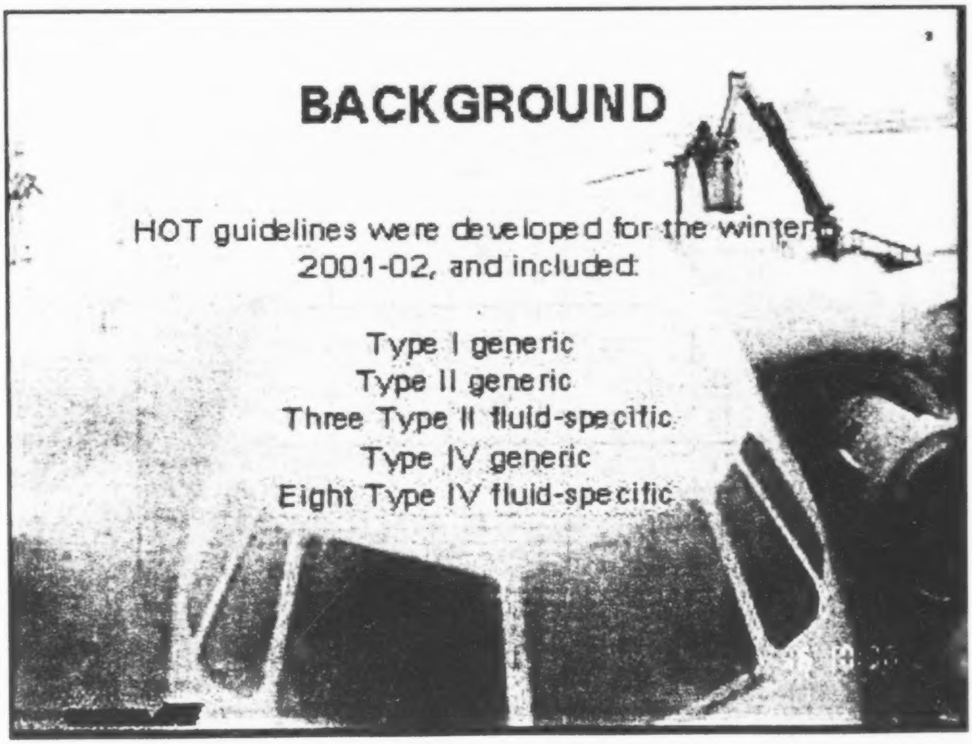
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

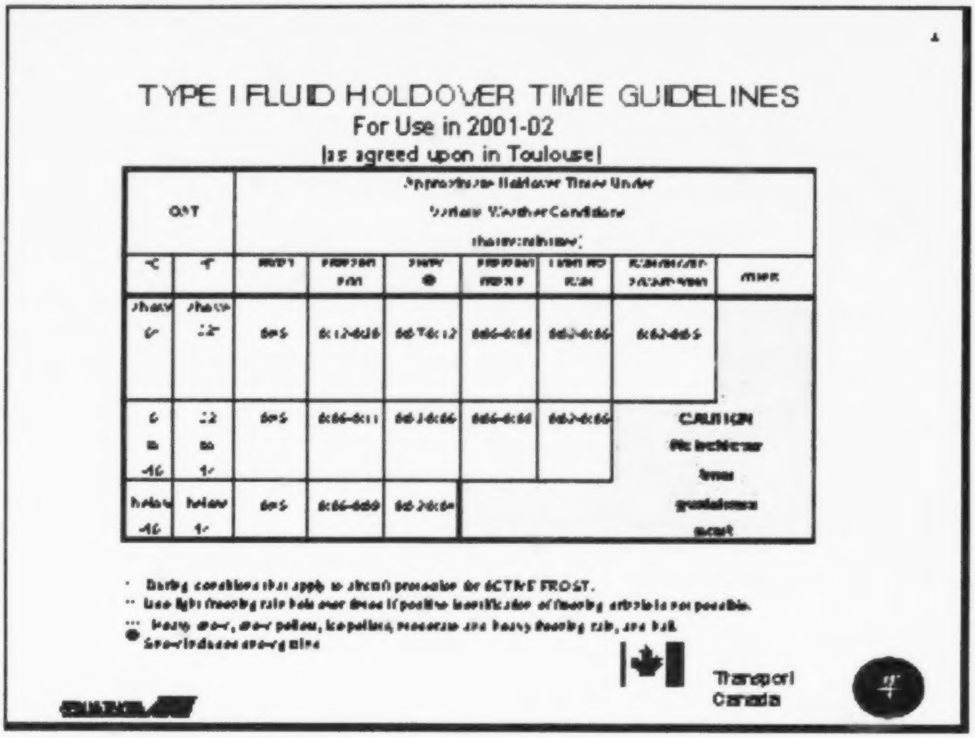
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



BACKGROUND

HOT guidelines were developed for the winter 2001-02, and included:

Type I generic
Type II generic
Three Type II fluid-specific
Type IV generic
Eight Type IV fluid-specific



TYPE I FLUID HOLDOVER TIME GUIDELINES

For Use in 2001-02

[as agreed upon in Toulouse]

OAT		[illegible]						
°C	°F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CAUTION [illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

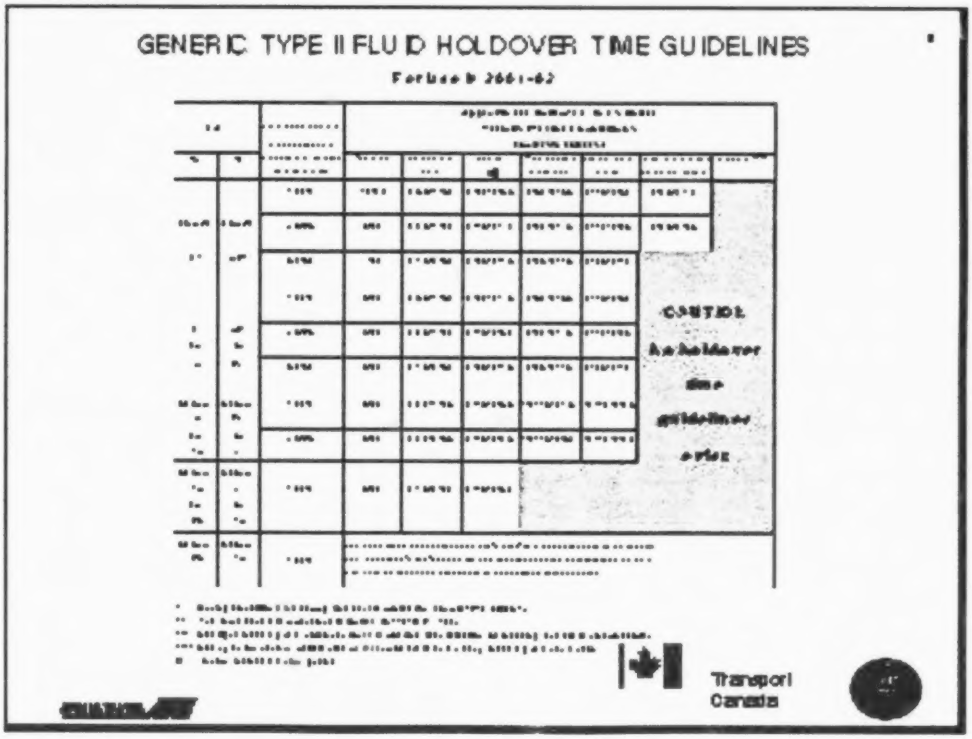
* [illegible] ACTIVE FROST.

** [illegible]

*** [illegible]

● [illegible]

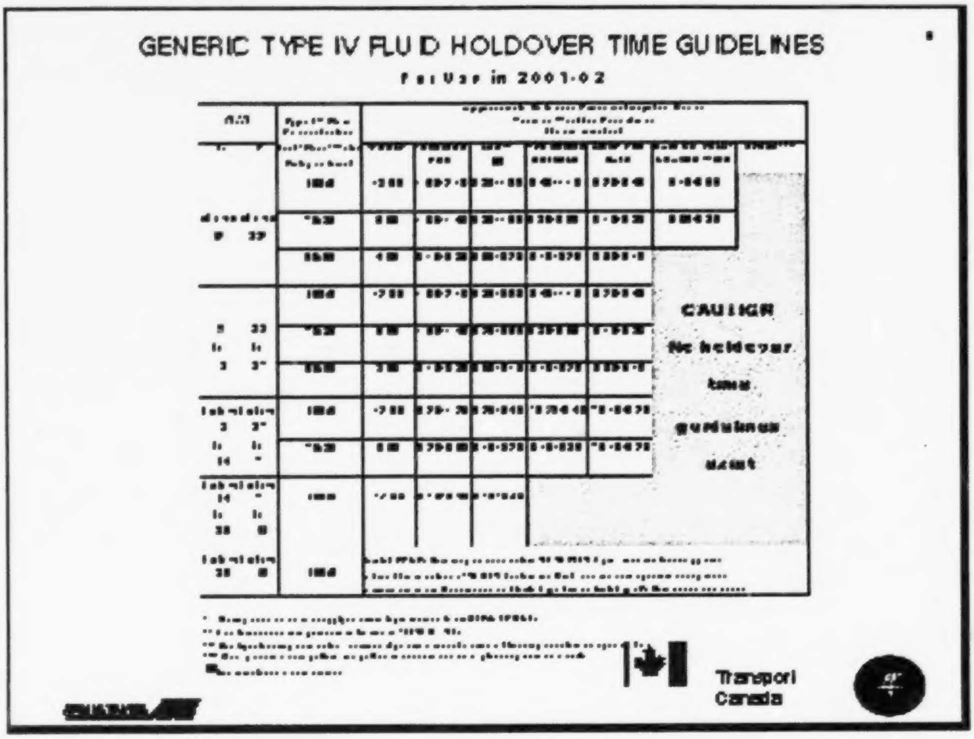
Transport Canada



GENERIC TYPE II FLUID HOLDOVER TIME GUIDELINES

[illegible]

Transport Canada

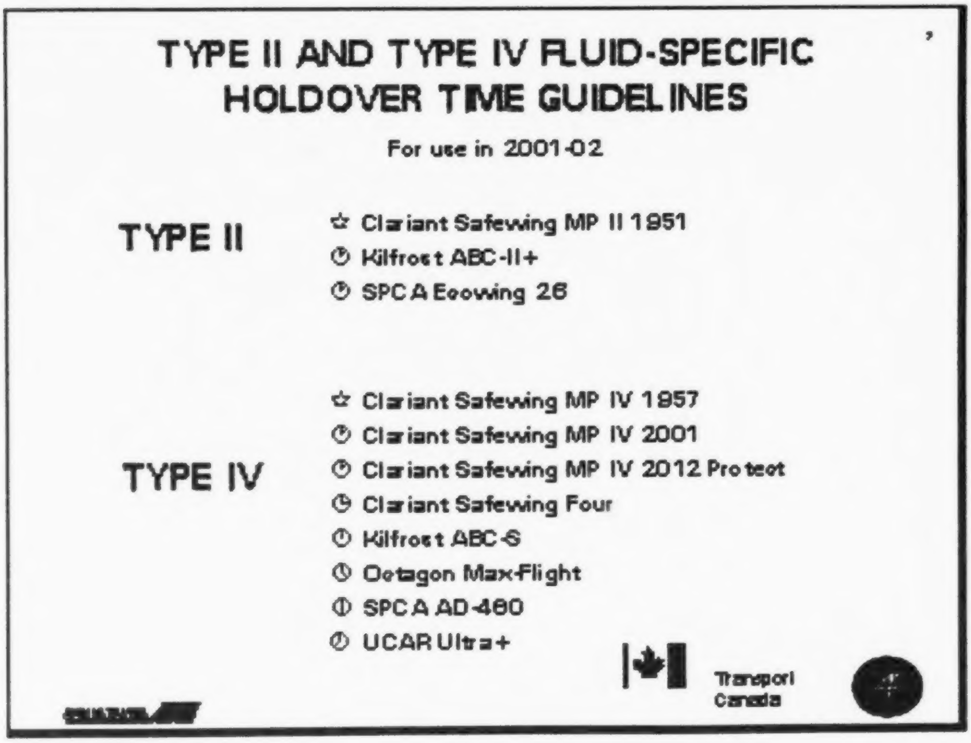


GENERIC TYPE IV FLUID HOLDOVER TIME GUIDELINES

For Use in 2001-02

CAUTION No holdover time guidelines exist

Transport Canada



TYPE II AND TYPE IV FLUID-SPECIFIC HOLDOVER TIME GUIDELINES

For use in 2001-02

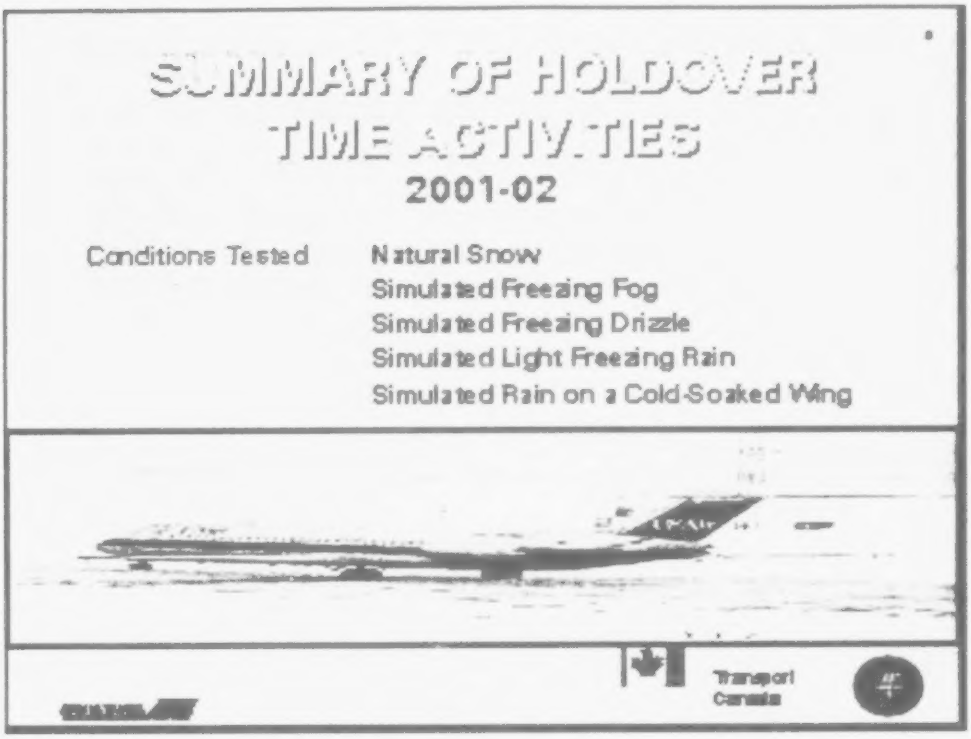
TYPE II

- ☆ Clariant Safewing MP II 1951
- ⏲ Kilfrost ABC-II+
- ⏲ SPCA Ecowing 26

TYPE IV

- ☆ Clariant Safewing MP IV 1957
- ⏲ Clariant Safewing MP IV 2001
- ⏲ Clariant Safewing MP IV 2012 Protect
- ⏲ Clariant Safewing Four
- ⏲ Kilfrost ABC-S
- ⏲ Octagon Max-Flight
- ⏲ SPCA AD-480
- ⏲ UCAR Ultra+

Transport Canada

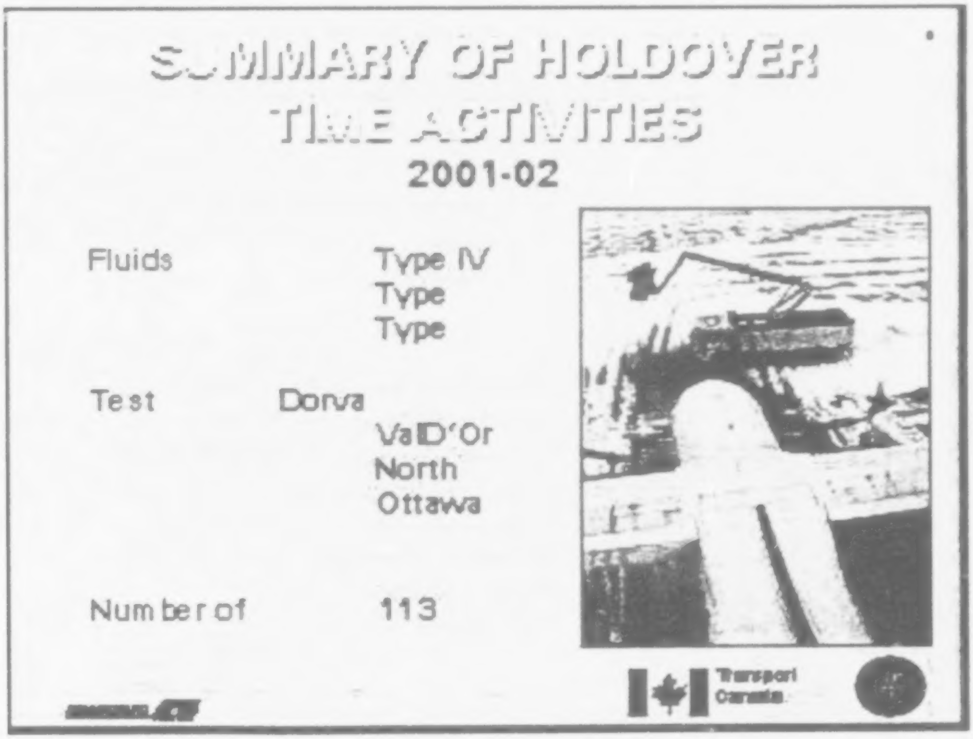


SUMMARY OF HOLDOVER TIME ACTIVITIES

2001-02

Conditions Tested
- Natural Snow
- Simulated Freezing Fog
- Simulated Freezing Drizzle
- Simulated Light Freezing Rain
- Simulated Rain on a Cold-Soaked Wing

Transport Canada



SUMMARY OF HOLDOVER TIME ACTIVITIES

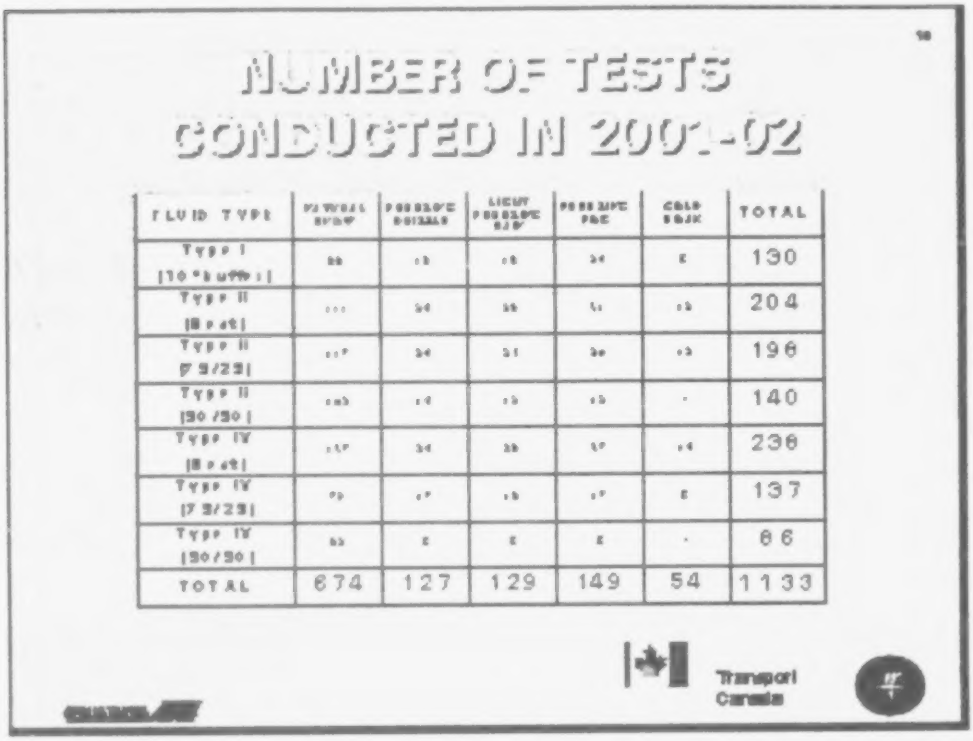
2001-02

Fluids Type IV
Type
Type

Test Dorva
ValD'Or
North
Ottawa

Number of 113

Transport Canada



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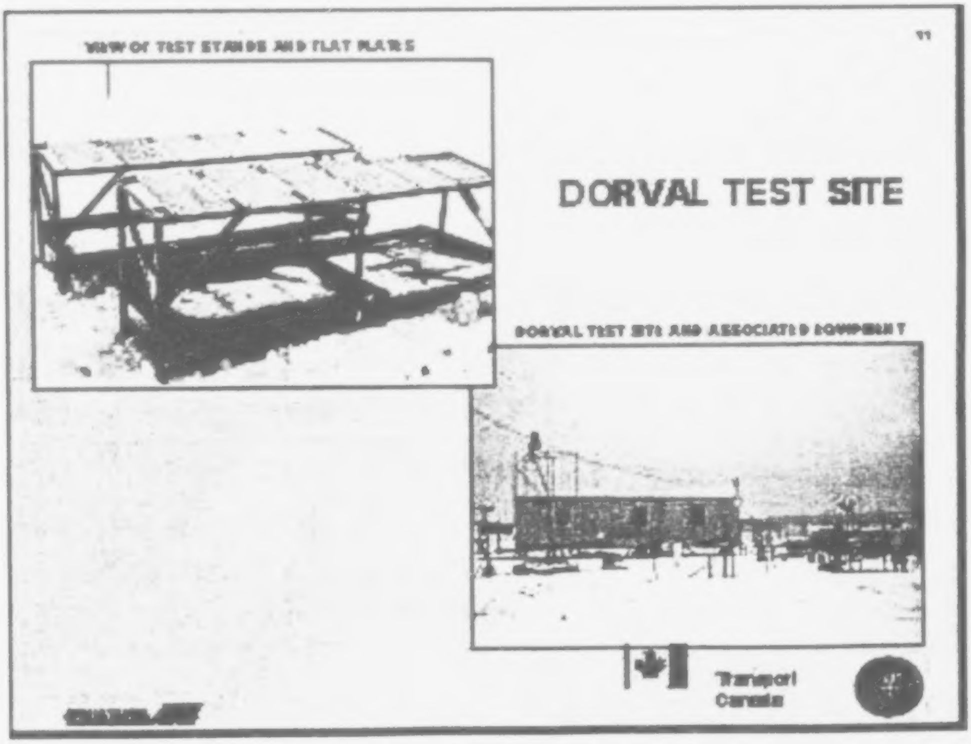
NUMBER OF TESTS CONDUCTED IN 2001-02

FLUID TYPE	NATURAL SNOW	FREEZING DRIZZLE	LIGHT FREEZING RAIN	FREEZING FOG	COLD SOAK	TOTAL
Type I (10° buffer)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	130
Type II (Neat)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	204
Type II (75/25)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	196
Type II (50/50)	[illegible]	[illegible]	[illegible]	[illegible]	-	140
Type IV (Neat)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	236
Type IV (75/25)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	137
Type IV (50/50)	[illegible]	[illegible]	[illegible]	[illegible]	-	86
TOTAL	674	127	129	149	54	1133

Transport Canada



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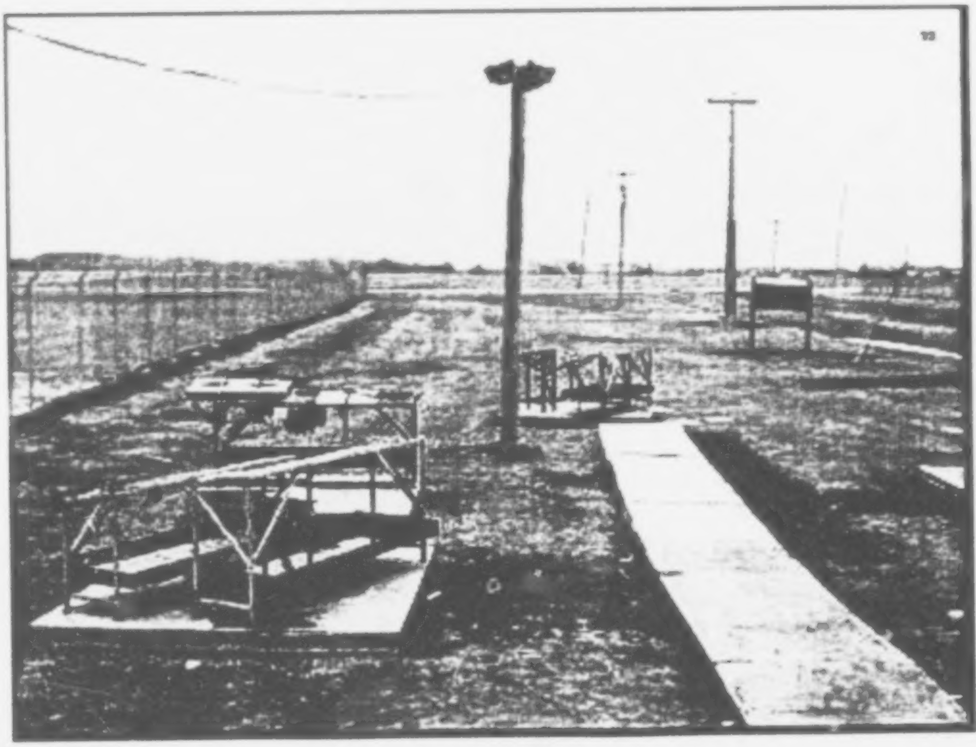
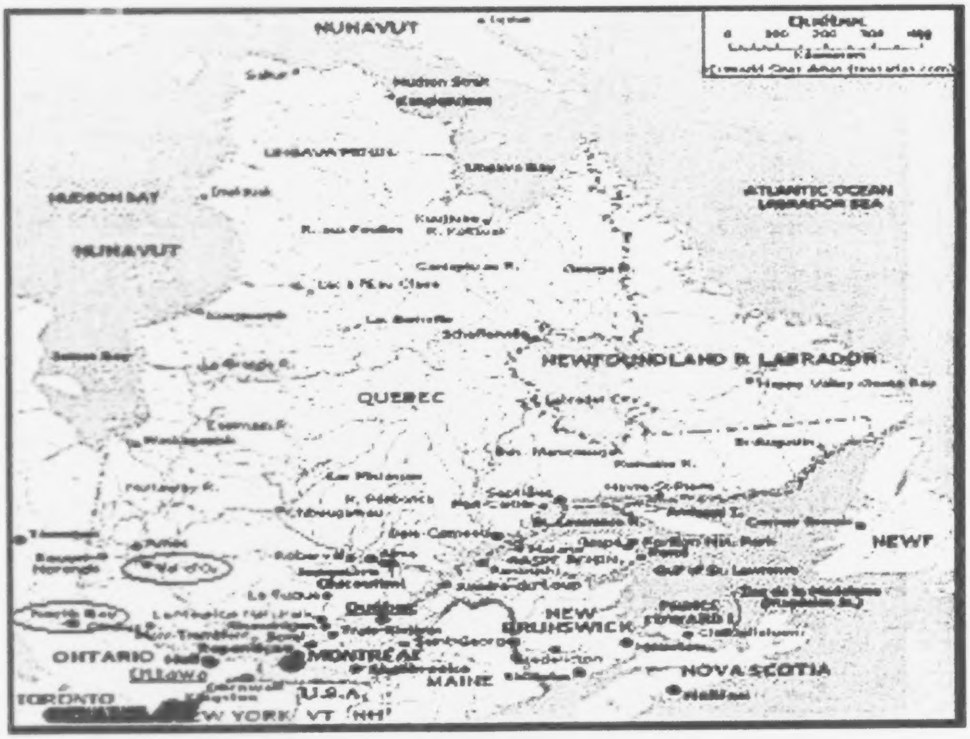
VIEW OF TEST STANDS AND FLAT PLATES

DORVAL TEST SITE

DORVAL TEST SITE AND ASSOCIATED EQUIPMENT

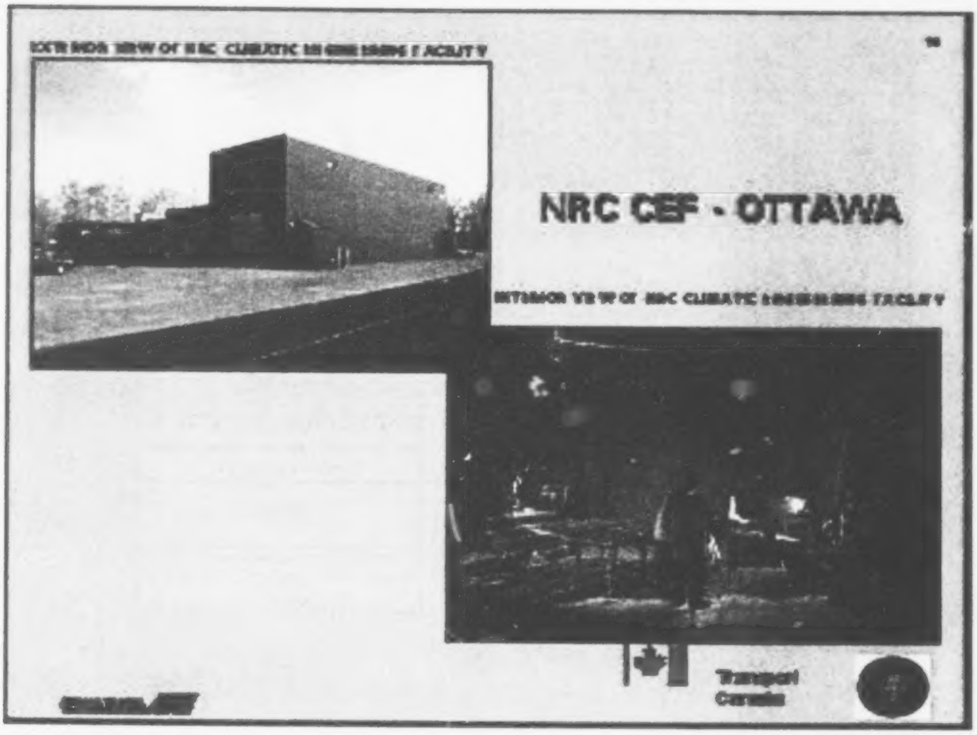
Transport Canada




NUNAVUT
Hudson Strait
Ungava Bay
HUDSON BAY
NUNAVUT
ATLANTIC OCEAN
LABRADOR SEA
George R.
Schefferville
James Bay
La Grande R.
NEWFOUNDLAND & LABRADOR
Happy Valley-Goose Bay
QUEBEC
Labrador City
Sept-Îles
St. Lawrence R.
NEWF
Gulf of St. Lawrence
Val-d'Or
North Bay
NEW BRUNSWICK
PRINCE EDWARD I.
Charlottetown
ONTARIO
Ottawa
MONTREAL
Quebec
MAINE
NOVA SCOTIA
Halifax
TORONTO
U.S.A.
NEW YORK
VT
NH

NORTH BAY, ONTARIO

VAL D'OR, QUEBEC

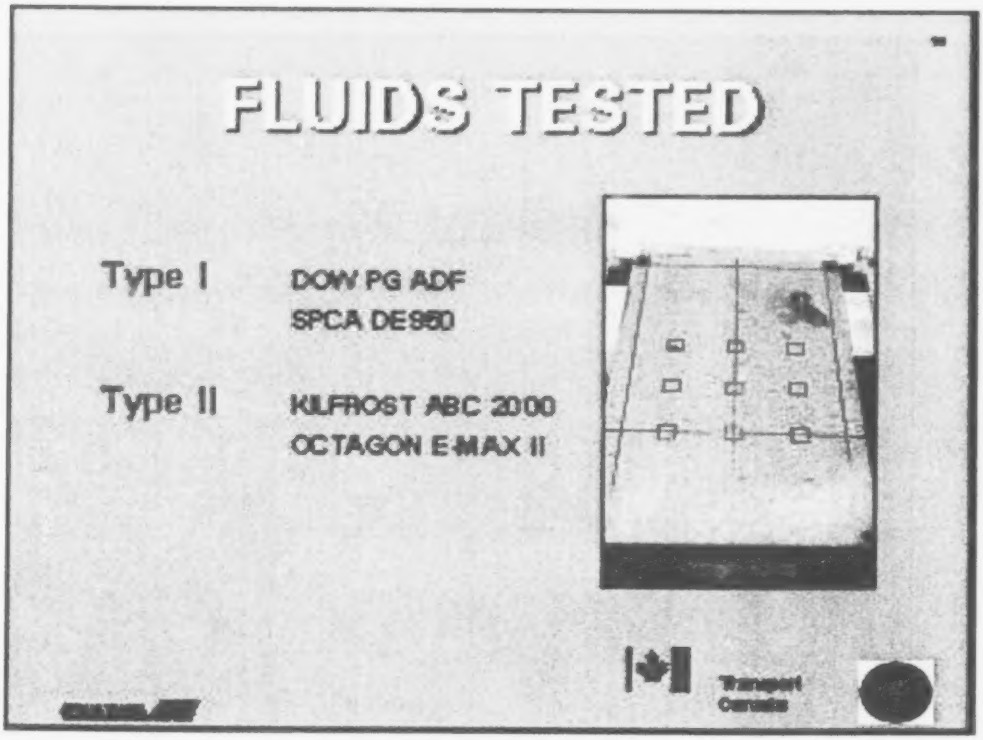


EXTERIOR VIEW OF NRC CLIMATIC ENGINEERING FACILITY

NRC CEF - OTTAWA

INTERIOR VIEW OF NRC CLIMATIC ENGINEERING FACILITY

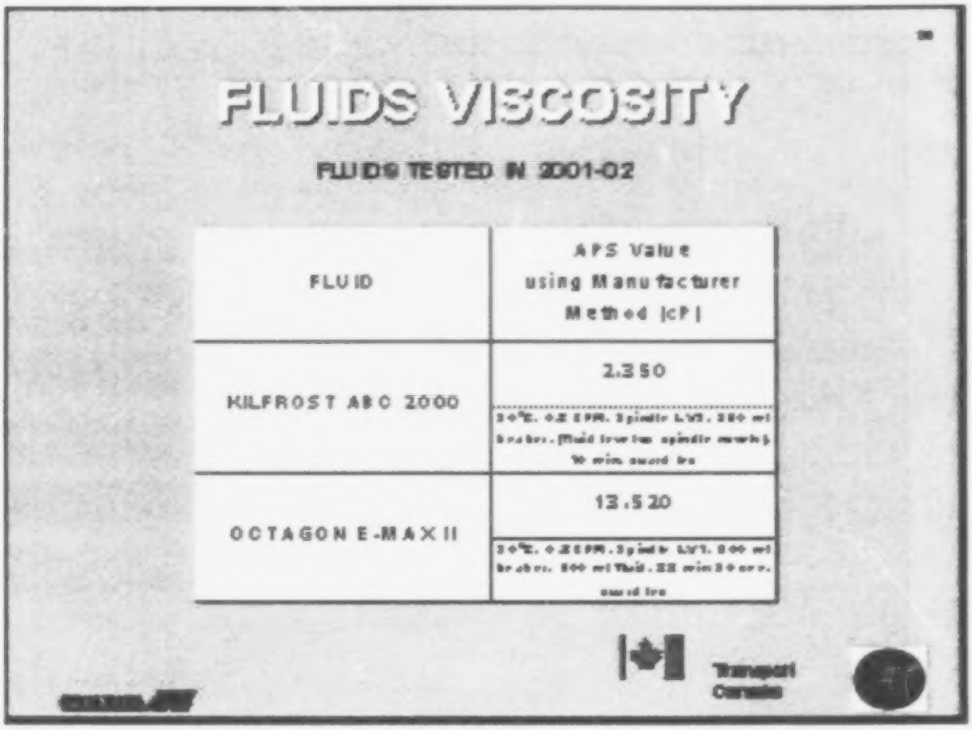
Transport Canada



FLUIDS TESTED

Type I	DOW PG ADF SPCA DE950
Type II	KILFROST ABC 2000 OCTAGON E-MAX II

Transport Canada

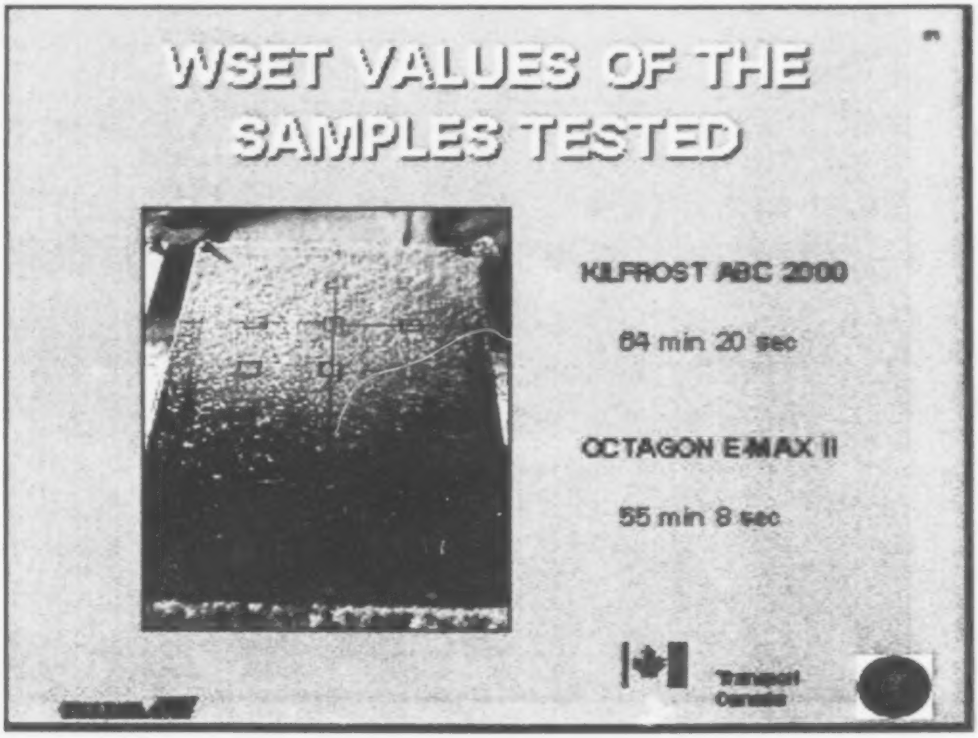


FLUIDS VISCOSITY

FLUIDS TESTED IN 2001-02

FLUID	APS Value using Manufacturer Method [cP]
KILFROST ABC 2000	2,350 [illegible]
OCTAGON E-MAX II	13,520 [illegible]

Transport Canada



WSET VALUES OF THE SAMPLES TESTED

KILFROST ABC 2000

64 min 20 sec

OCTAGON E-MAX II

55 min 8 sec

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REGRESSION APPROACH

- Regression analysis that provides a power law relationship was used for each fluid and each dilution for each weather condition.
- General form of the equation for light freezing rain, freezing drizzle, freezing fog, and rain on a cold-soaked wing is $t = cR^a$
- General form of the equation for snow is $t = cR^aT^b$

where
t = Time,
R = Rate of precipitation,
T = Temperature, and
a, b, c = The coefficients determined from the regression.

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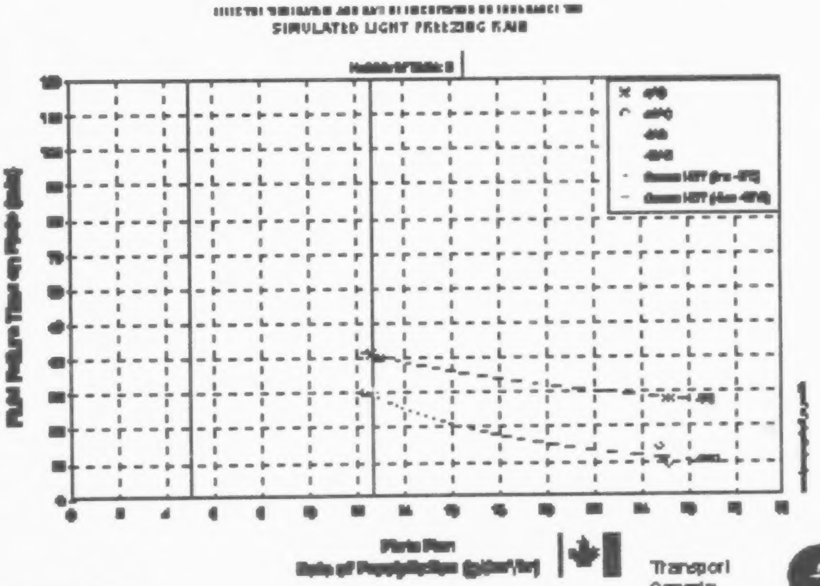
EXAMPLE OF REGRESSION ANALYSIS



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SUMMARY OF PROCEDURE USED TO DETERMINE HOLDOVER TIME LIMITS

For Each Fluid for Each Cell

- **Curves were plotted for each fluid and each cell of the holdover time table using the MOST RESTRICTIVE TEMPERATURE for that cell.**
- **Upper and lower holdover time values were determined using the data ranges specified on the next page.**

Determination of SAE (*Worst Case*) Holdover Time Table Values

- **Select the lowest Lower Limit and lowest Upper Limit by inspection of the values of the *fluid-specific* tables.**
- **Round numbers to the nearest whole "5" value.**
- **For safety reasons, holdover times below 10 minutes were always rounded down.**

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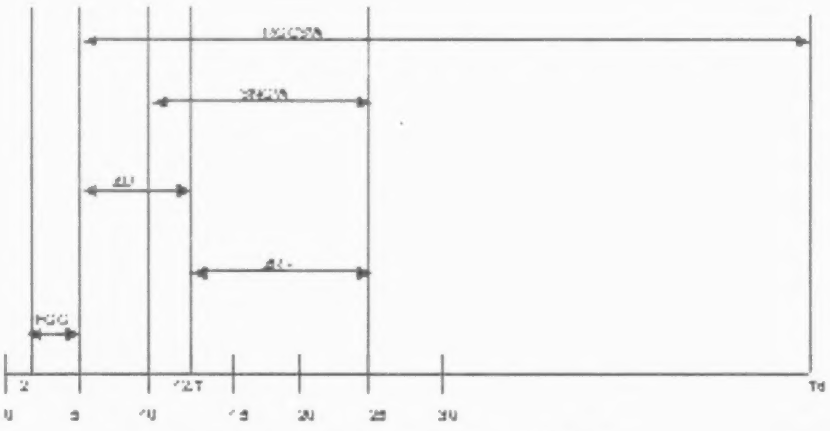
DATA RANGES USED FOR EVALUATION OF HOLDOVER TIME LIMITS



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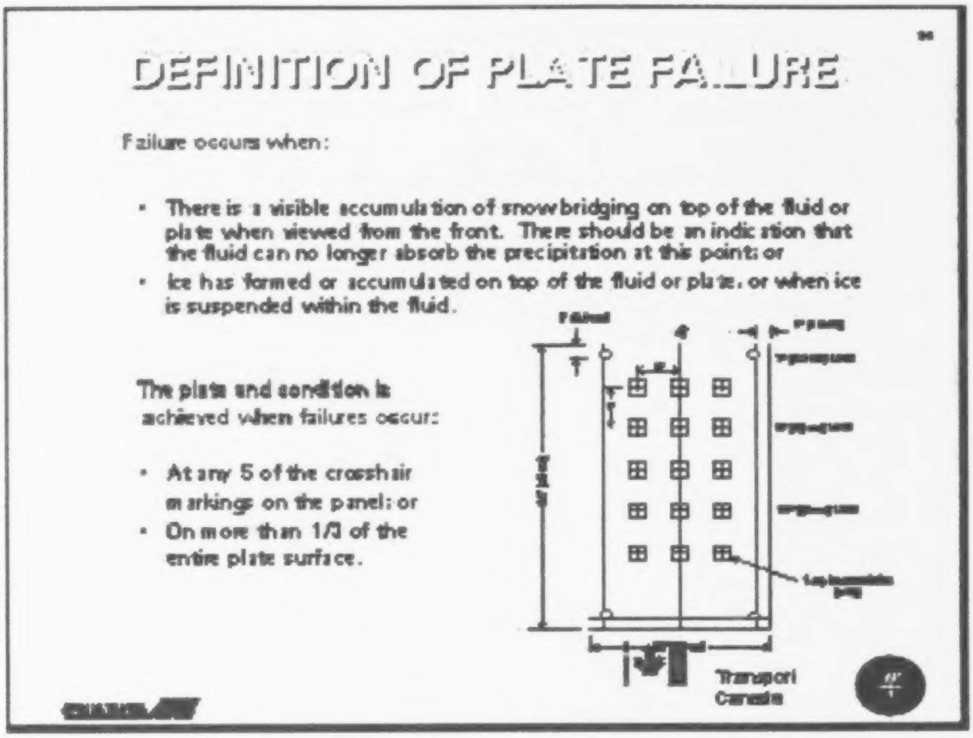


DEFINITION OF PLATE FAILURE

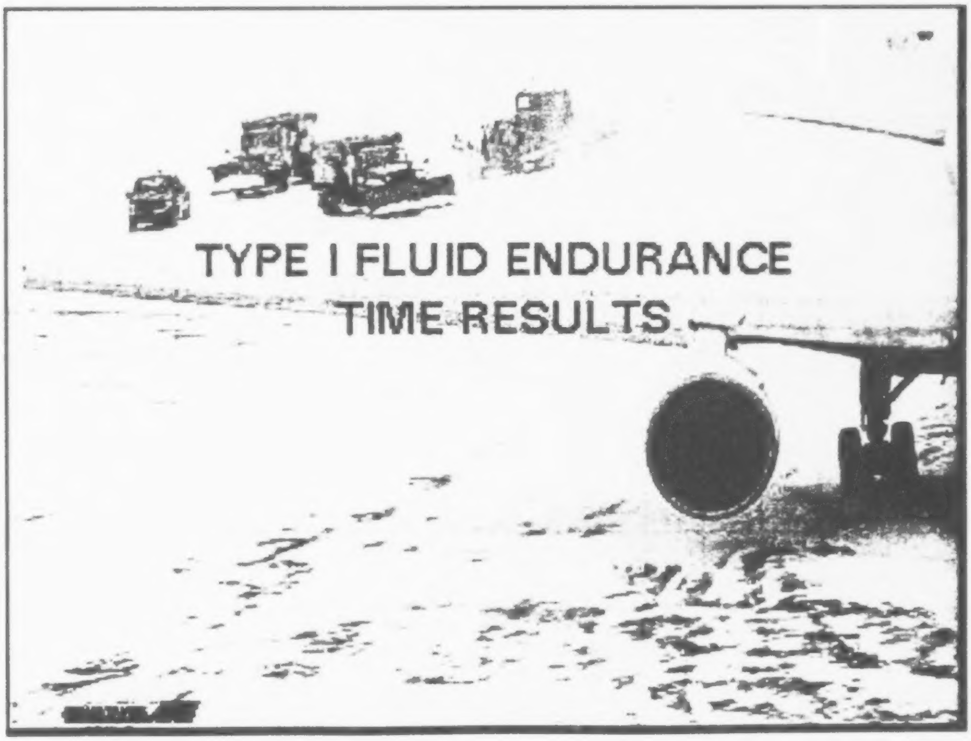
Failure occurs when:

- There is a visible accumulation of snowbridging on top of the fluid or plate when viewed from the front. There should be an indication that the fluid can no longer absorb the precipitation at this point; or
- Ice has formed or accumulated on top of the fluid or plate, or when ice is suspended within the fluid.

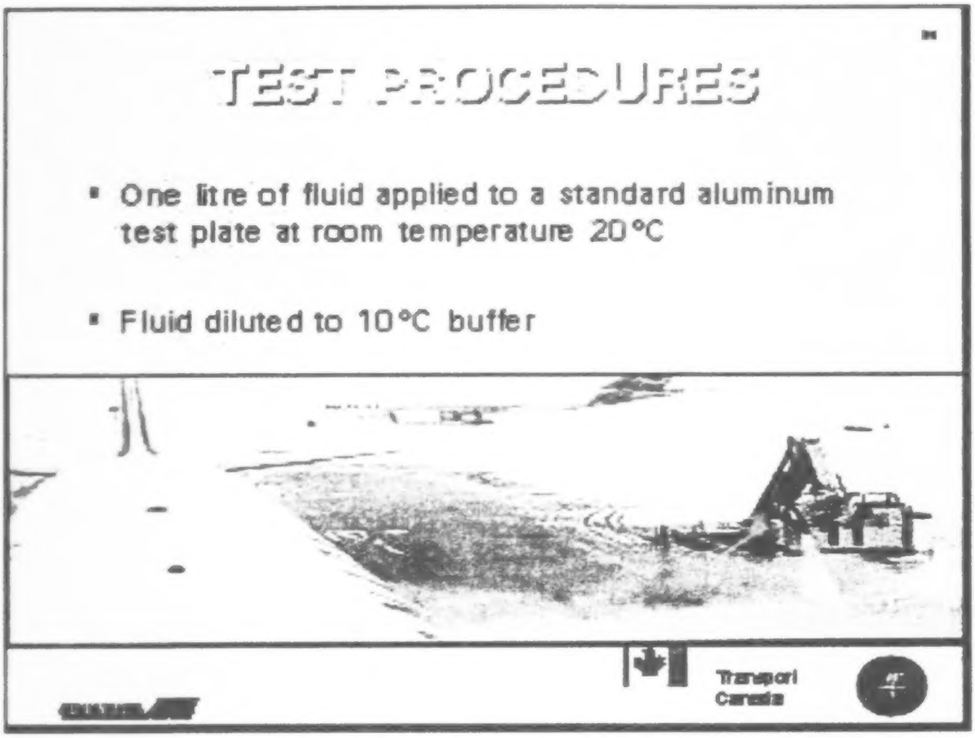
The plate end condition is achieved when failures occur:

- At any 5 of the crosshair markings on the panel; or
- On more than 1/3 of the entire plate surface.

Transport Canada



TYPE I FLUID ENDURANCE TIME RESULTS



TEST PROCEDURES

- One litre of fluid applied to a standard aluminum test plate at room temperature 20°C
- Fluid diluted to 10°C buffer

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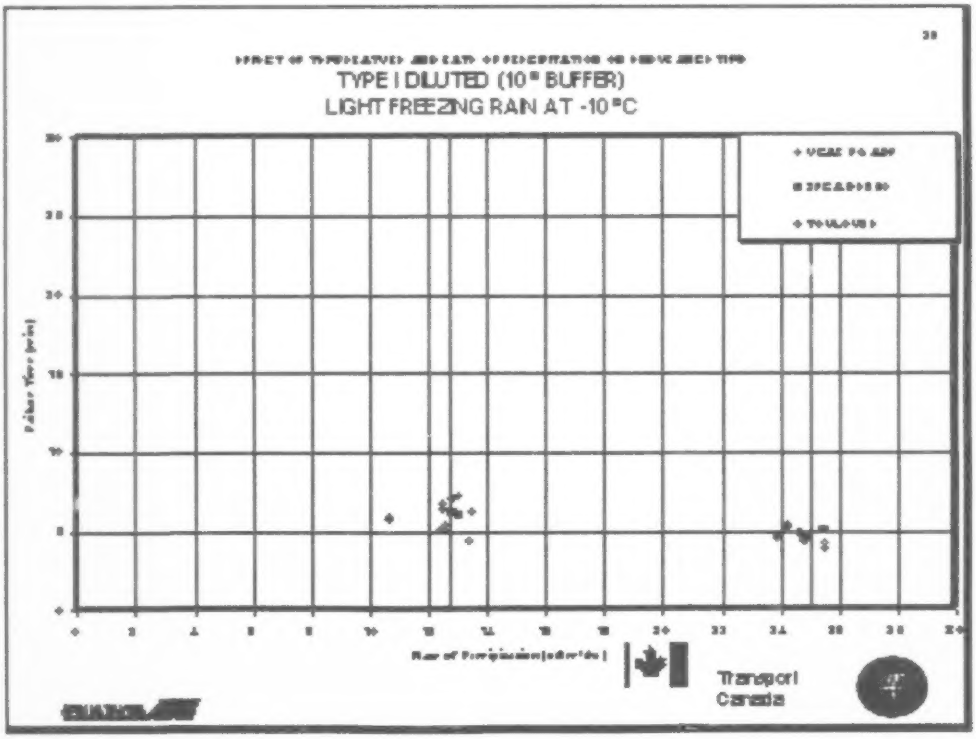

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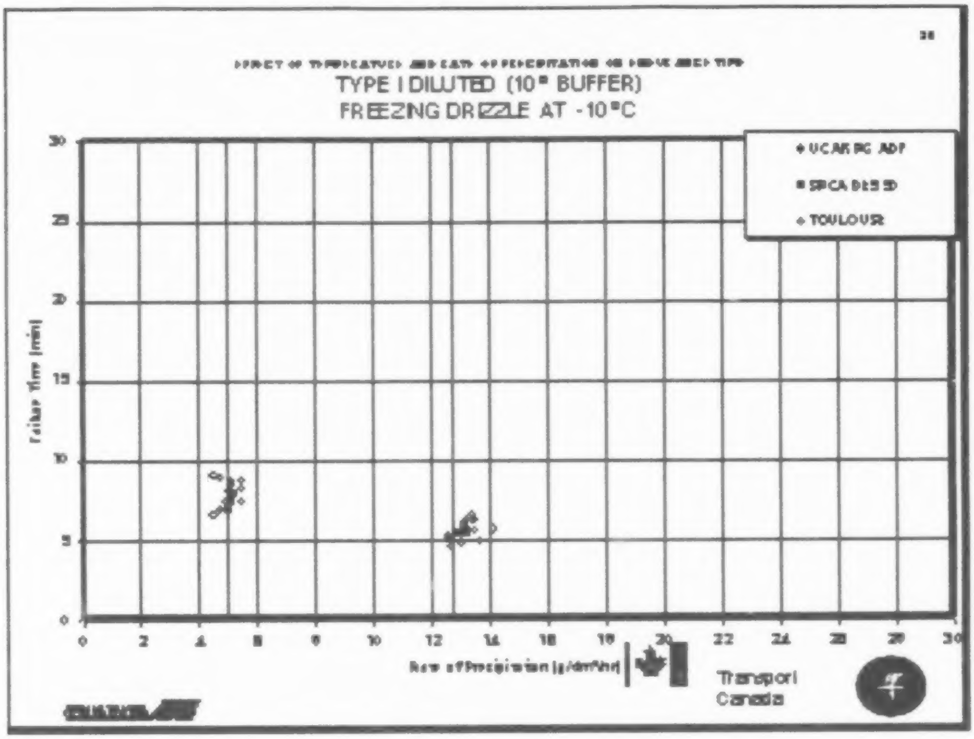
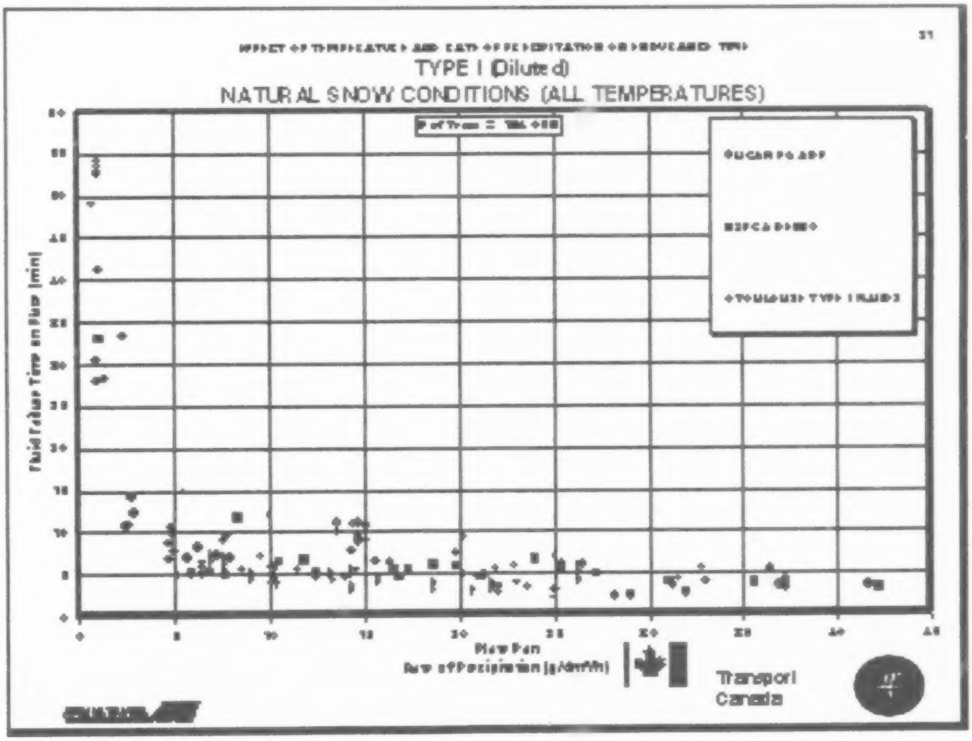
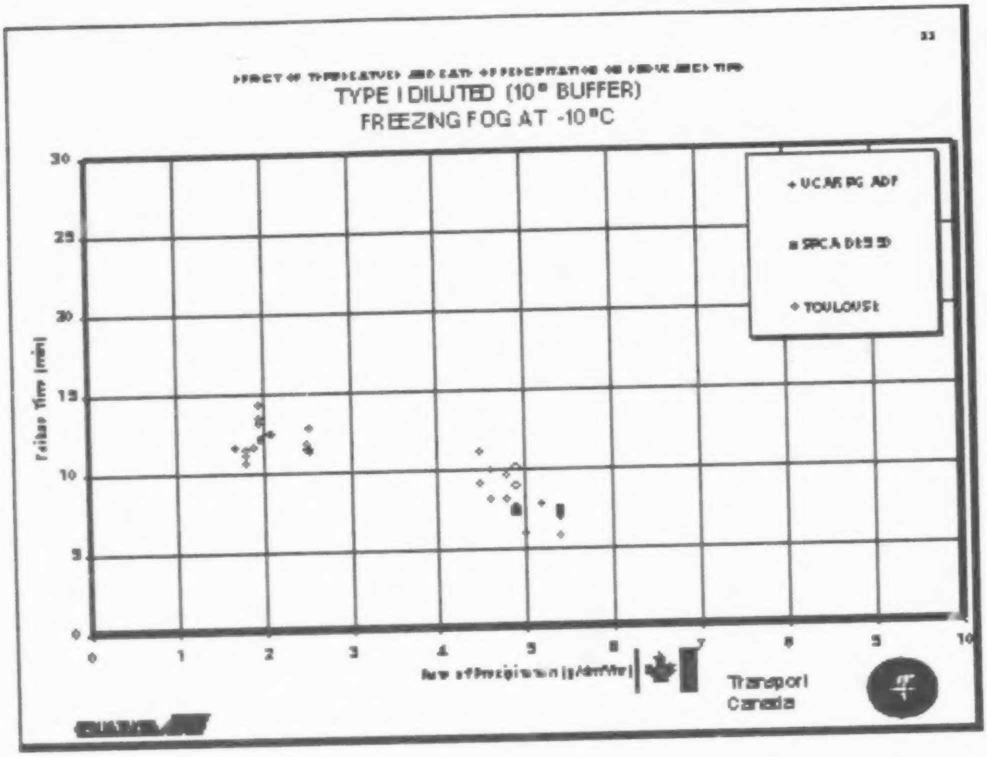
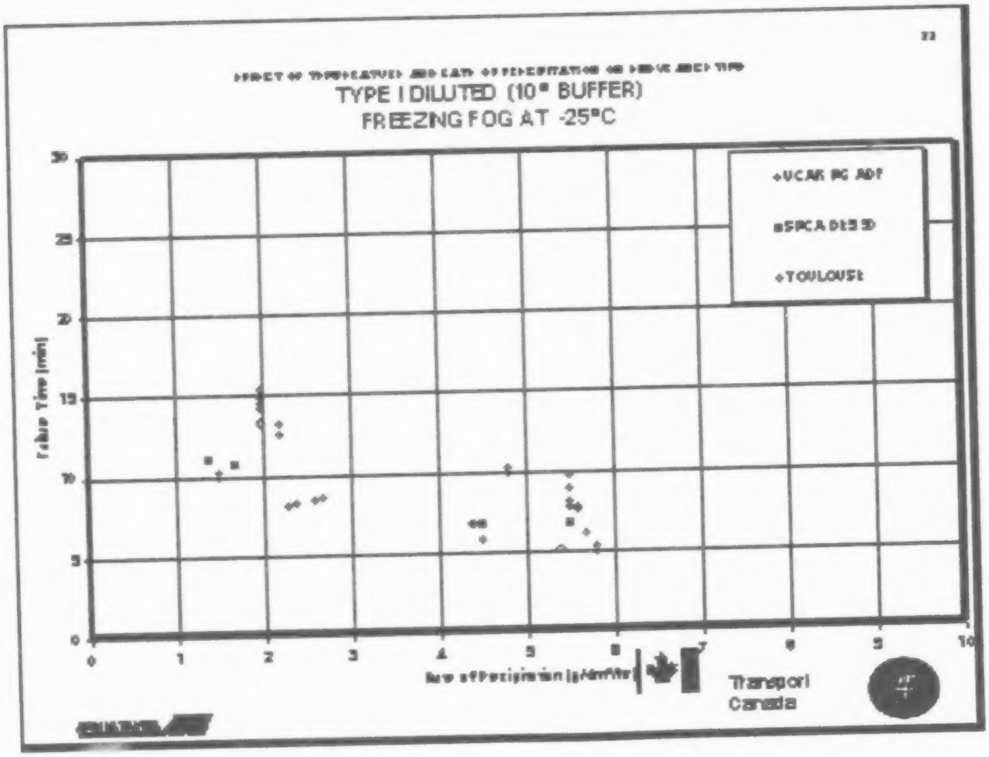
TYPE I DILUTED (10° BUFFER)
LIGHT FREEZING RAIN AT -10°C

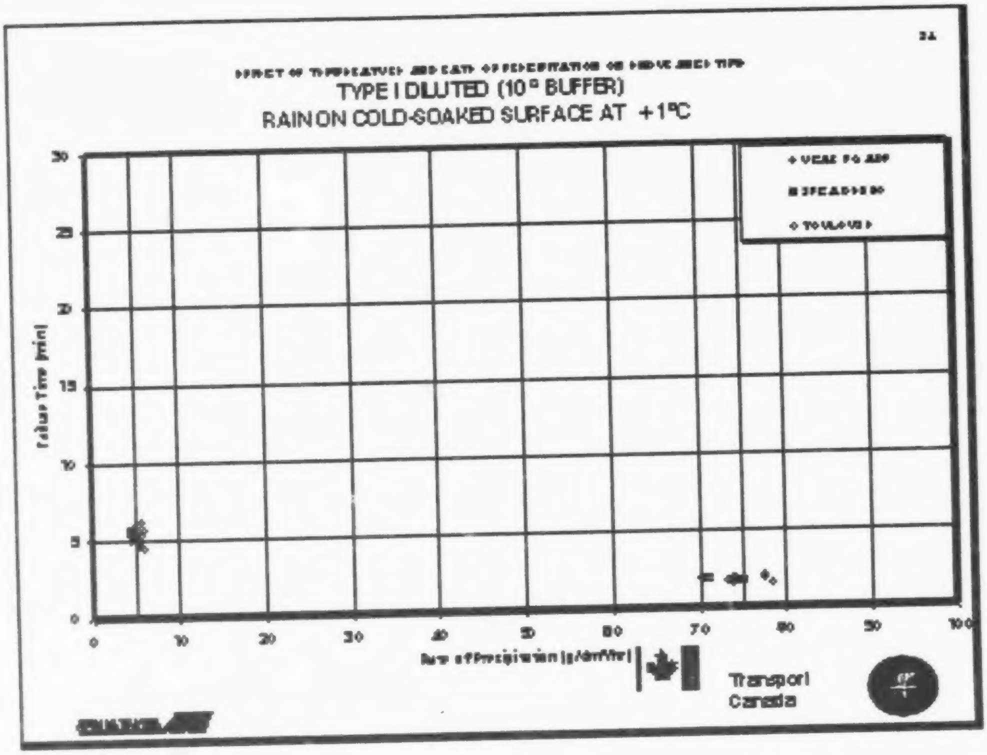
Transport Canada


TYPE I DILUTED (10° BUFFER)
FREEZING DRIZZLE AT -10°C
UCAR PG ADF
TOULOUSE
Failure Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Rate of Precipitation (g/dm²/hr)
Transport Canada

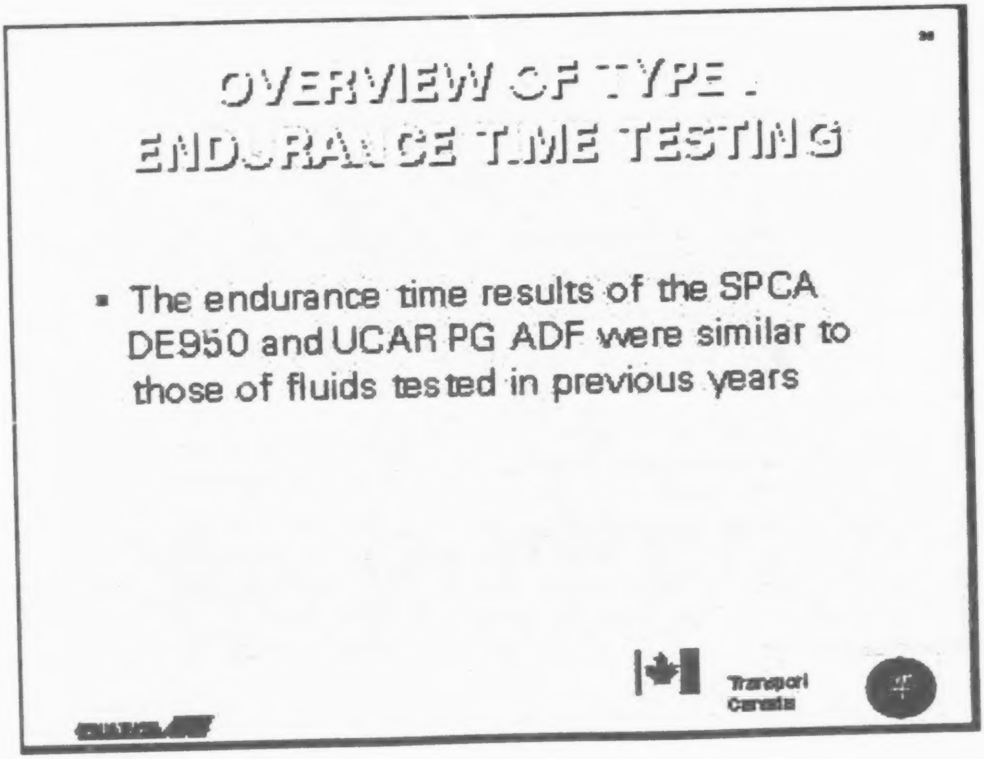

TYPE I (Diluted)
NATURAL SNOW CONDITIONS (ALL TEMPERATURES)
UCAR PG ADF
TOULOUSE TYPE I FLUID
Fluid Failure Time on Plate (min)
0
5
10
15
20
25
30
35
40
45
Rate of Precipitation (g/dm²/hr)
Transport Canada


TYPE I DILUTED (10° BUFFER)
FREEZING FOG AT -10°C
UCAR PG ADF
SPCA DE535
TOULOUSE
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/hr)
0
1
2
3
4
5
6
7
8
9
10
Transport Canada


TYPE I DILUTED (10° BUFFER)
FREEZING FOG AT -25°C
UCAR PG ADF
SPCA DE535
TOULOUSE
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/hr)
0
1
2
3
4
5
6
7
8
9
10
Transport Canada



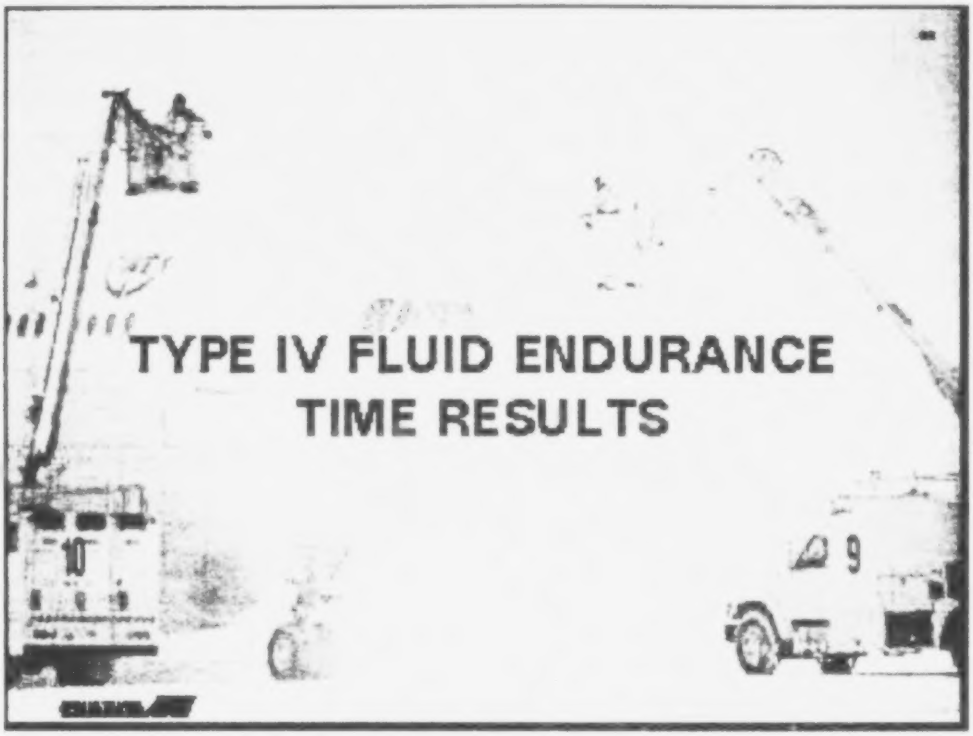
TYPE I DILUTED (10° BUFFER)
RAIN ON COLD-SOAKED SURFACE AT +1°C



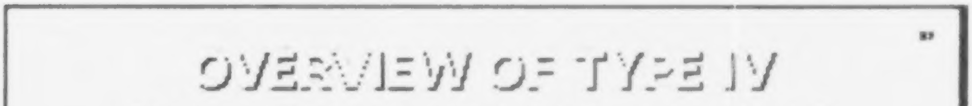
OVERVIEW OF TYPE I ENDURANCE TIME TESTING

- The endurance time results of the SPCA DE950 and UCAR PG ADF were similar to those of fluids tested in previous years

Transport Canada



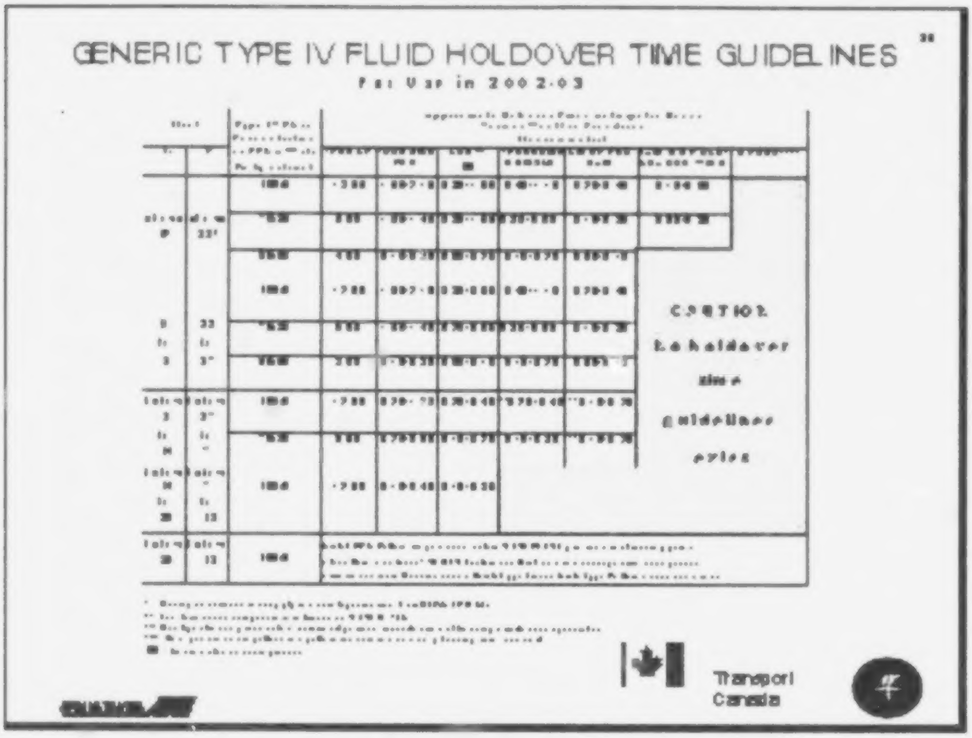
TYPE IV FLUID ENDURANCE TIME RESULTS



OVERVIEW OF TYPE IV ENDURANCE TIME TESTING

- Endurance time testing was conducted with 3 Type IV fluids in 2001-02
- None of the fluids will be commercially produced for 2002-03 winter operations
- Therefore, no changes will be made to the generic Type IV holdover time guidelines for use in 2002-03 winter operations.

Transport Canada

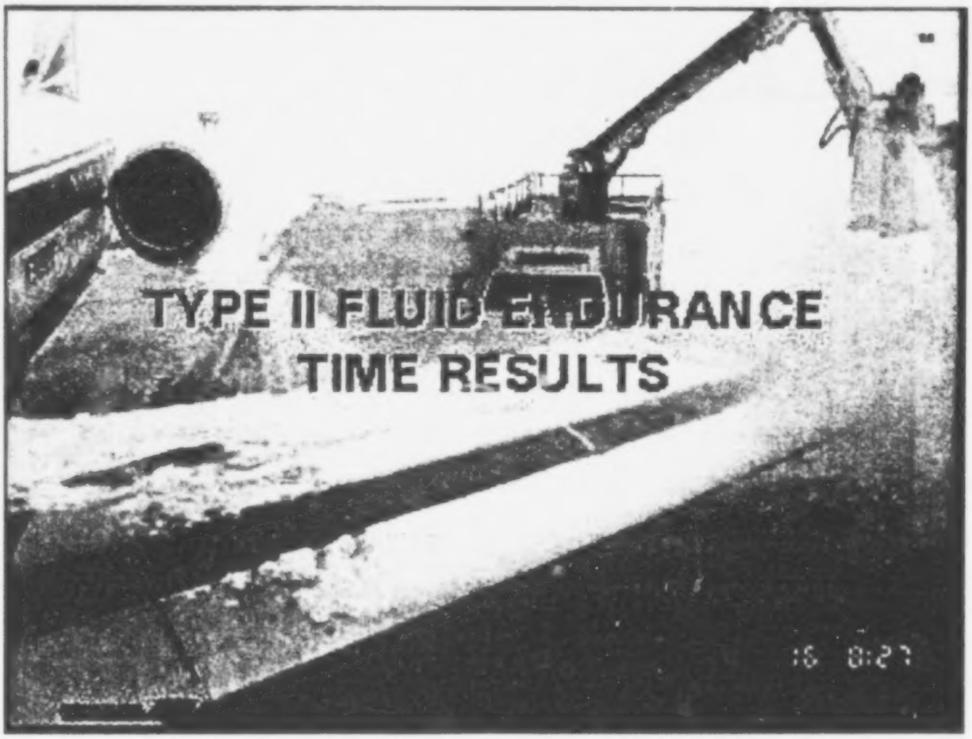


GENERIC TYPE IV FLUID HOLDOVER TIME GUIDELINES

For Use in 2002-03

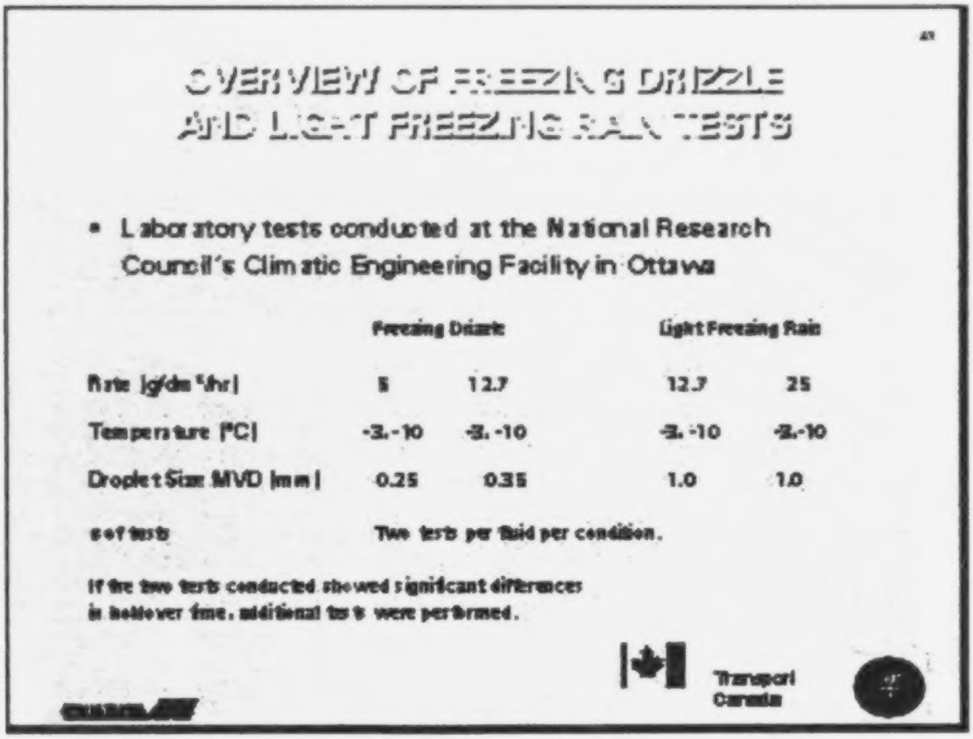
CAUTION
No holdover
time
guidelines
exist

Transport
Canada



TYPE II FLUID ENDURANCE TIME RESULTS

FREEZING DRIZZLE / LIGHT FREEZING RAIN



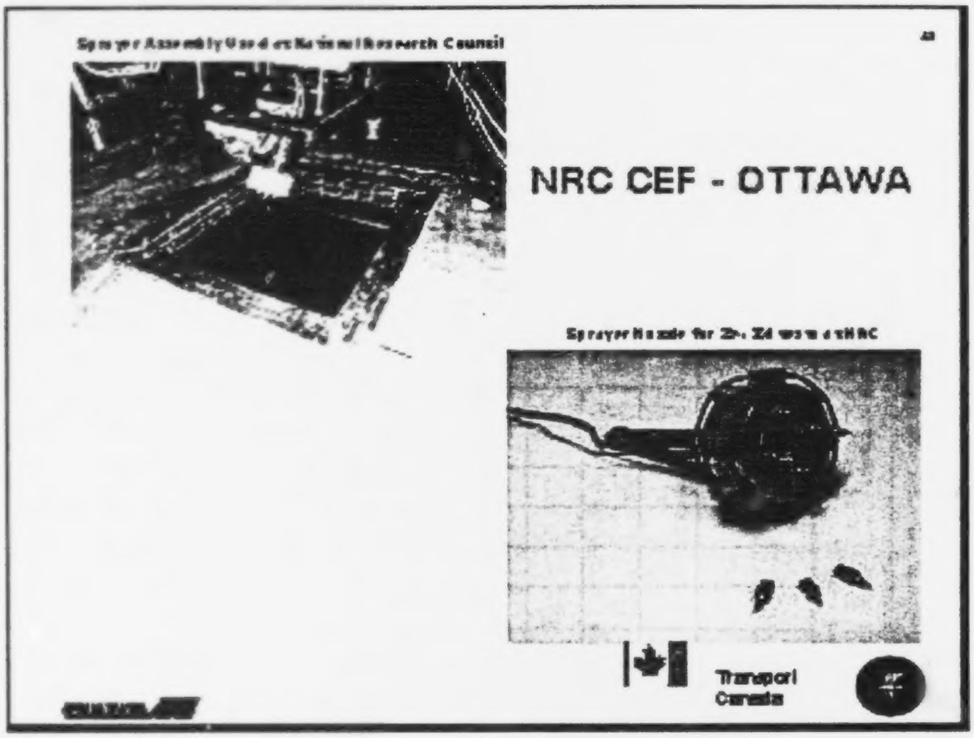
OVERVIEW OF FREEZING DRIZZLE AND LIGHT FREEZING RAIN TESTS

- Laboratory tests conducted at the National Research Council's Climatic Engineering Facility in Ottawa

	Freezing Drizzle		Light Freezing Rain	
Rate [g/dm²/hr]	5	12.7	12.7	25
Temperature [°C]	-3, -10	-3, -10	-3, -10	-3, -10
Droplet Size MVD [mm]	0.25	0.35	1.0	1.0
# of tests	Two tests per fluid per condition.			

If the two tests conducted showed significant differences in holdover time, additional tests were performed.

Transport Canada



Sprayer Assembly Used at National Research Council

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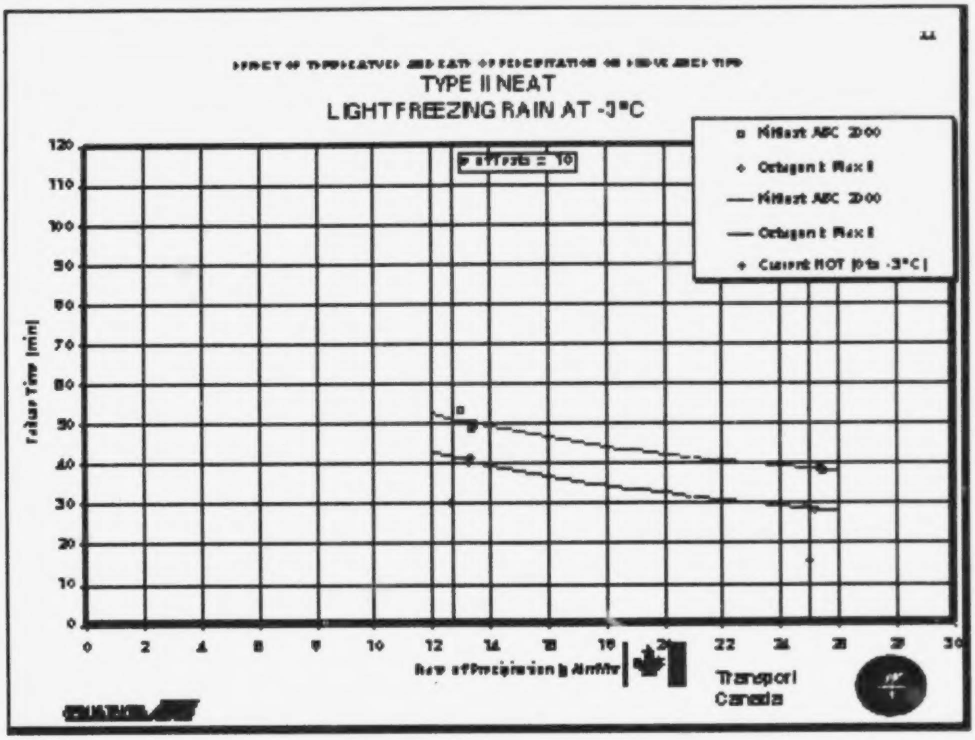
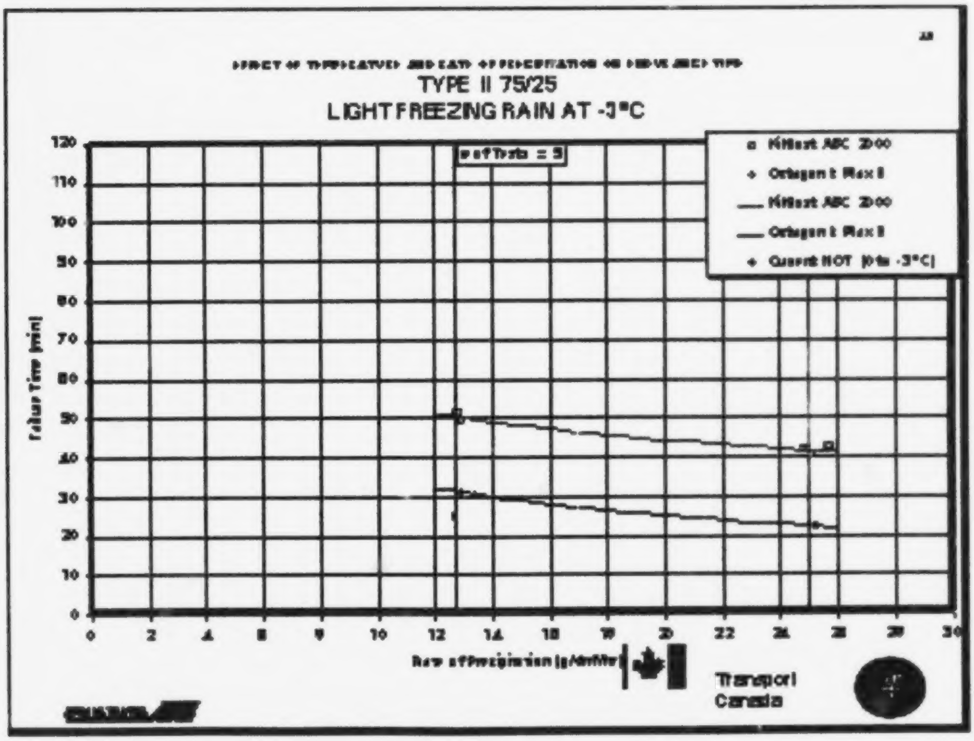
NRC CEF - OTTAWA

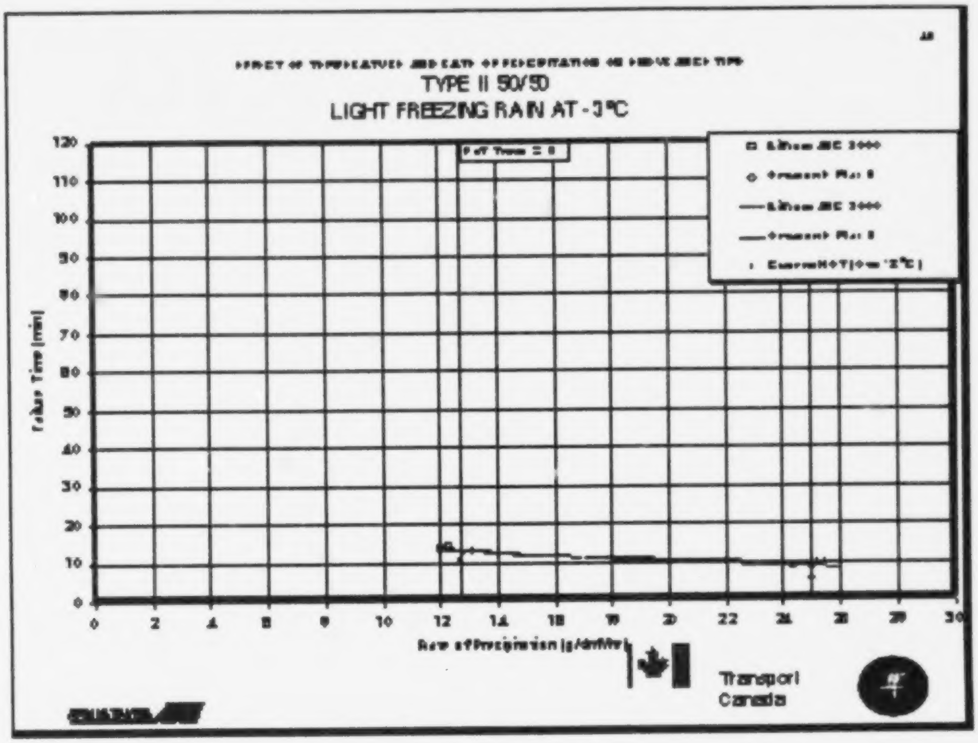
Sprayer Nozzle for ZR-, ZL used at NRC

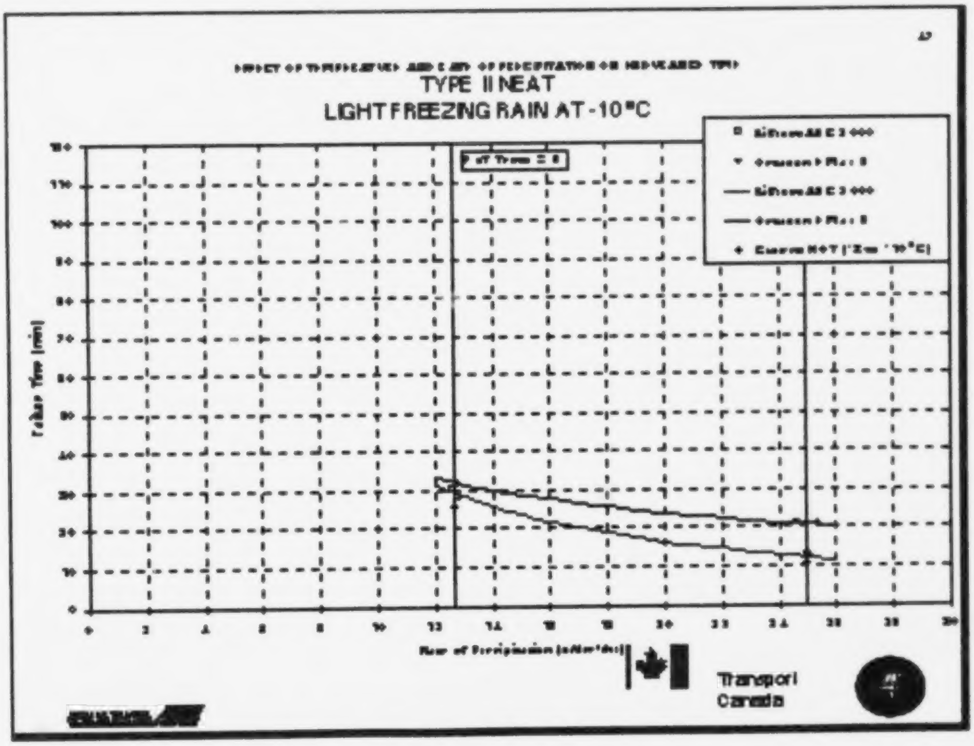
Transport Canada

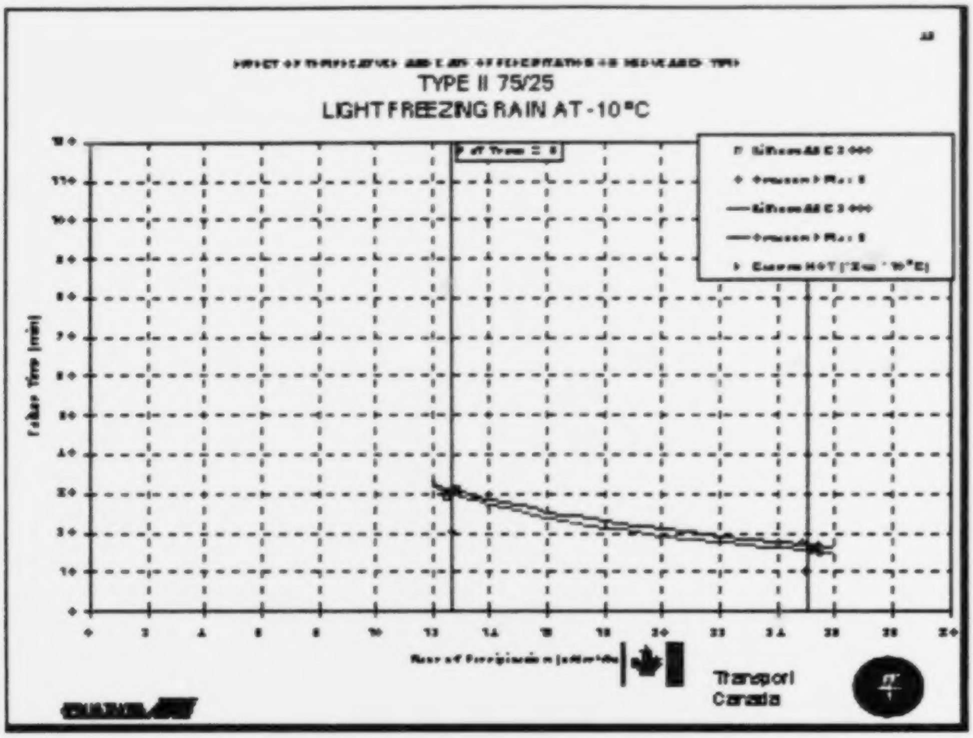
LIGHT FREEZING RAIN


TYPE II NEAT
LIGHT FREEZING RAIN AT -3°C
# of Tests = 10
Kilfrost ABC 2000
Octagon E Max II
Kilfrost ABC 2000
Octagon E Max II
Current HOT (0 to -3°C)
Failure Time (min)
120
110
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Rate of Precipitation (g/dm²/h)
Transport Canada

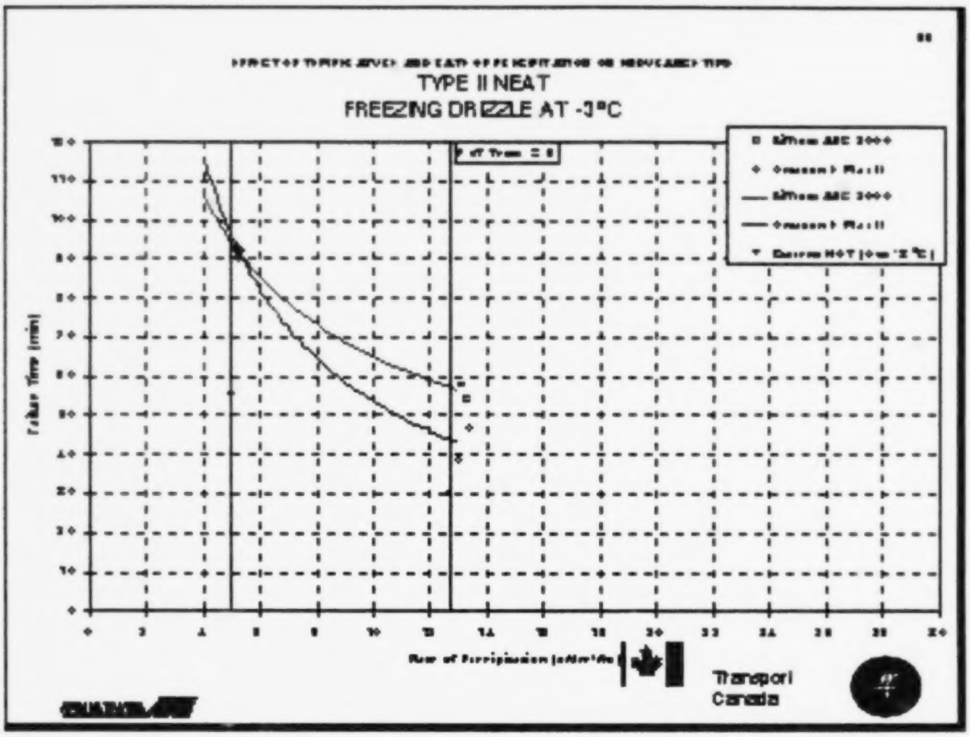

TYPE II 75/25
LIGHT FREEZING RAIN AT -3°C
# of Tests = 5
Kilfrost ABC 2000
Octagon E Max II
Kilfrost ABC 2000
Octagon E Max II
Current HOT (0 to -3°C)
Failure Time (min)
120
110
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Rate of Precipitation (g/dm²/h)
Transport Canada

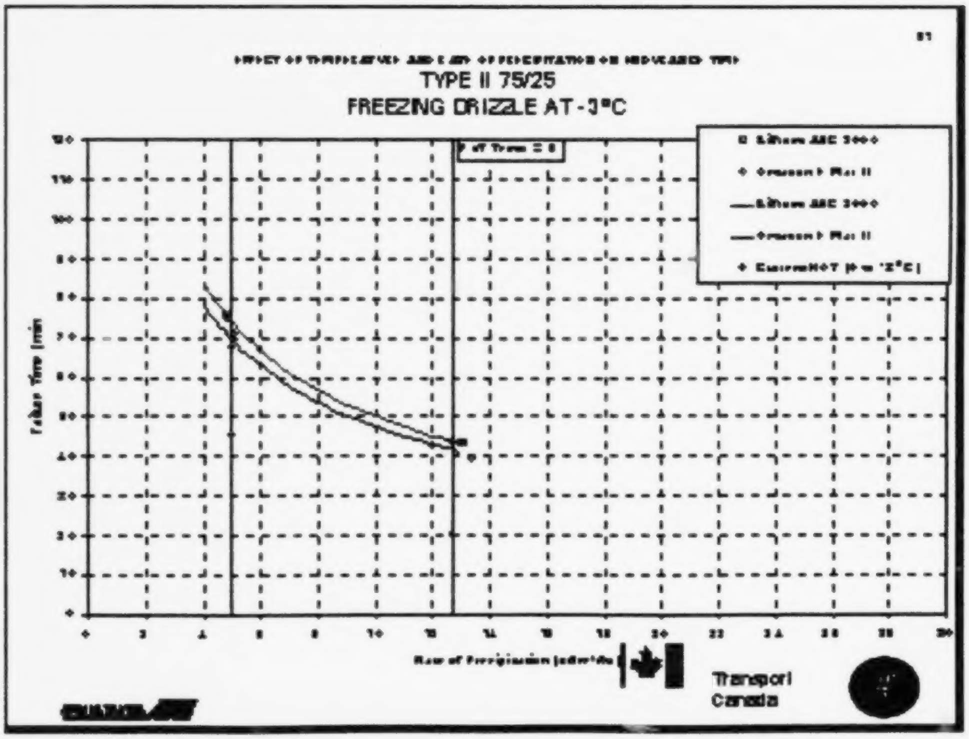

TYPE II 50/50
LIGHT FREEZING RAIN AT -3°C
120
110
100
90
80
70
60
50
40
30
20
10
0
Failure Time (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Transport
Canada

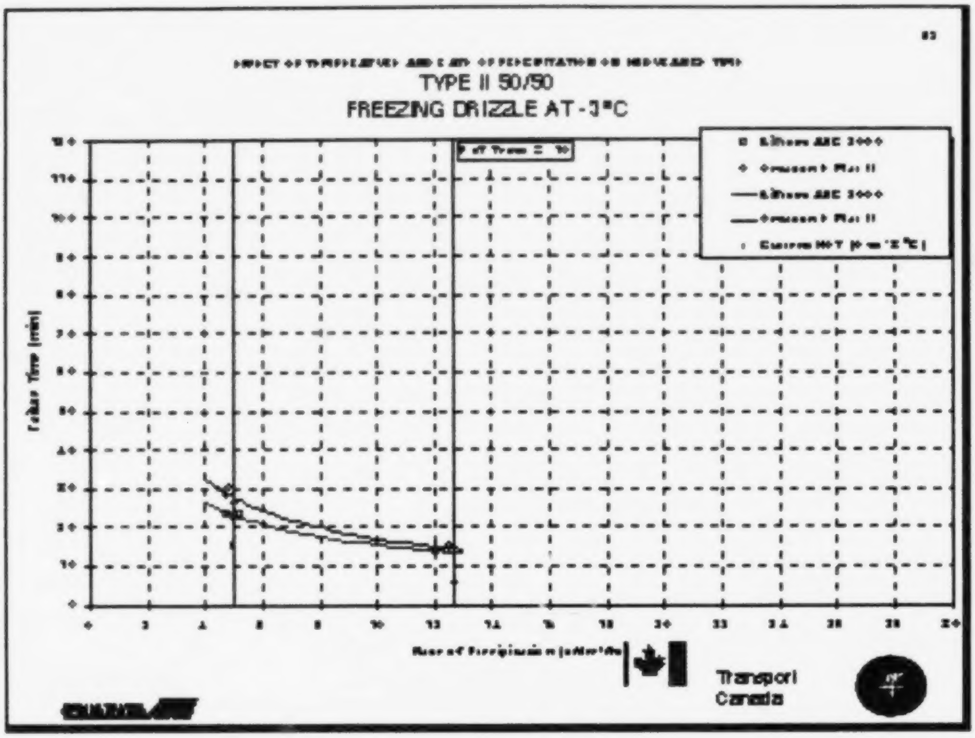

TYPE II NEAT
LIGHT FREEZING RAIN AT -10°C
Failure Time (min)
Transport
Canada


TYPE II 75/25
LIGHT FREEZING RAIN AT -10°C
Failure Time (min)
Transport Canada

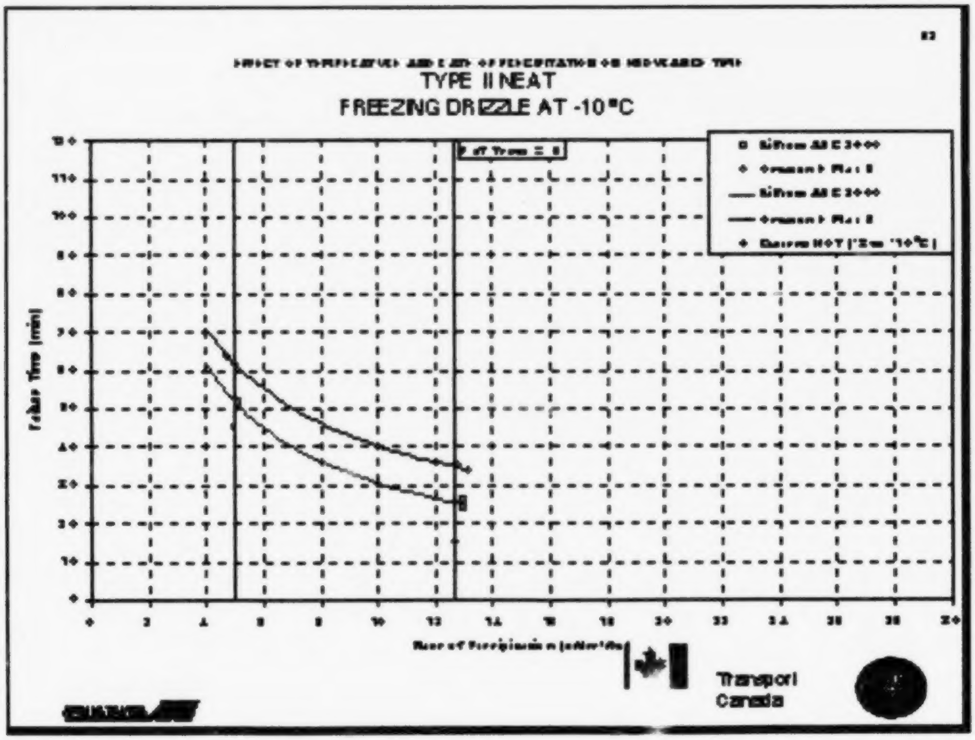
FREEZING DRIZZLE


TYPE II NEAT
FREEZING DRIZZLE AT -3°C

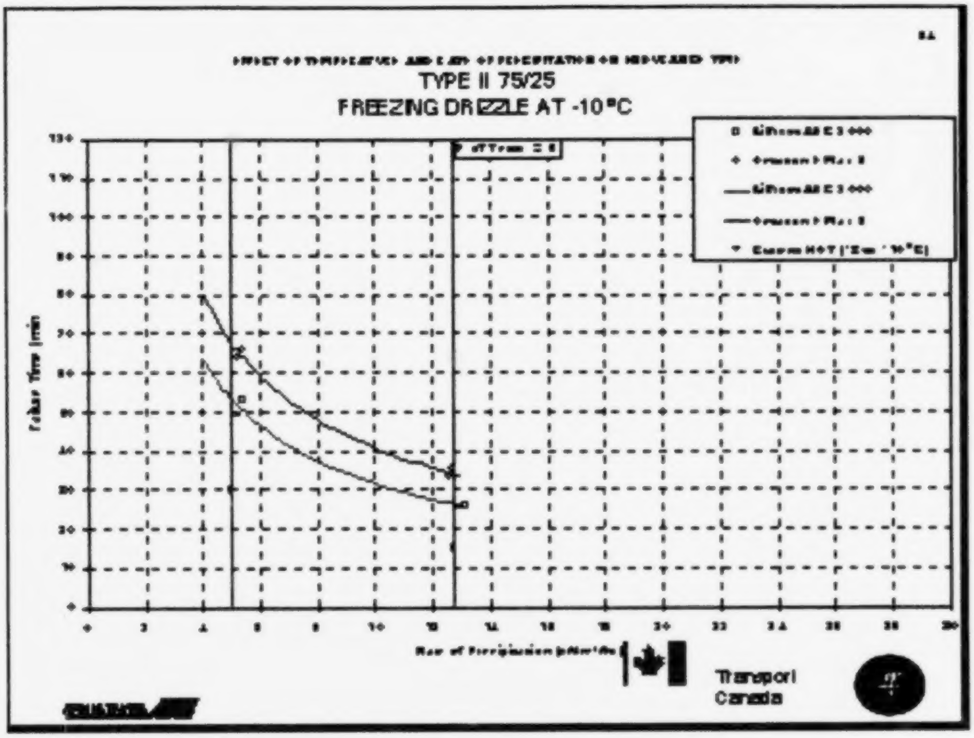

TYPE II 75/25
FREEZING DRIZZLE AT -3°C



TYPE II 50/50
FREEZING DRIZZLE AT -3°C



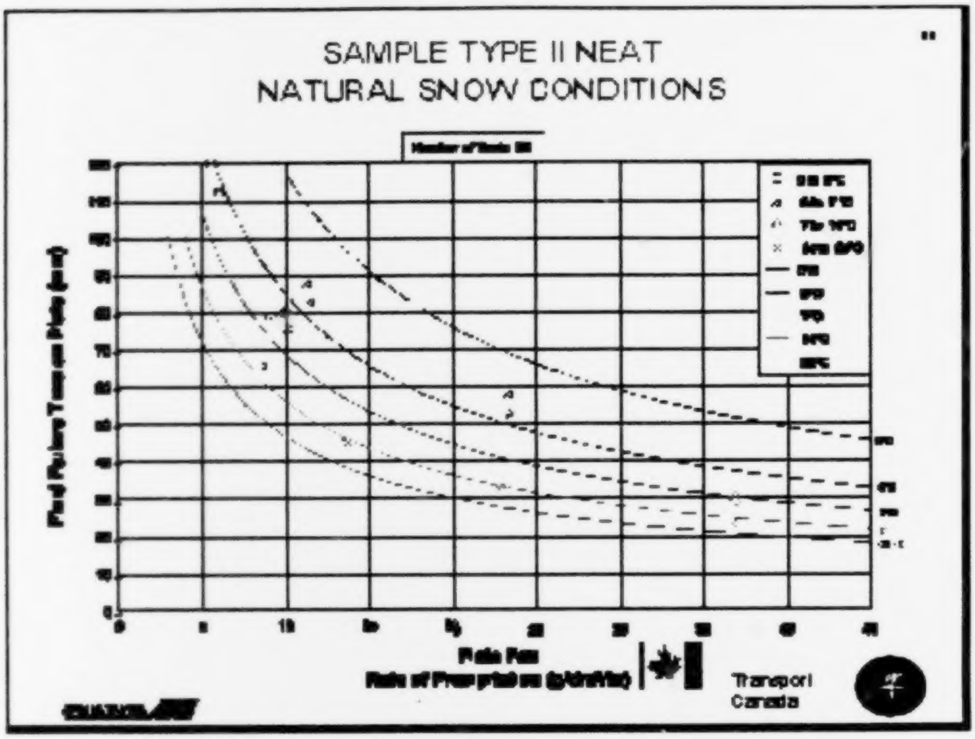
TYPE II NEAT
FREEZING DRIZZLE AT -10°C



TYPE II 75/25
FREEZING DRIZZLE AT -10°C

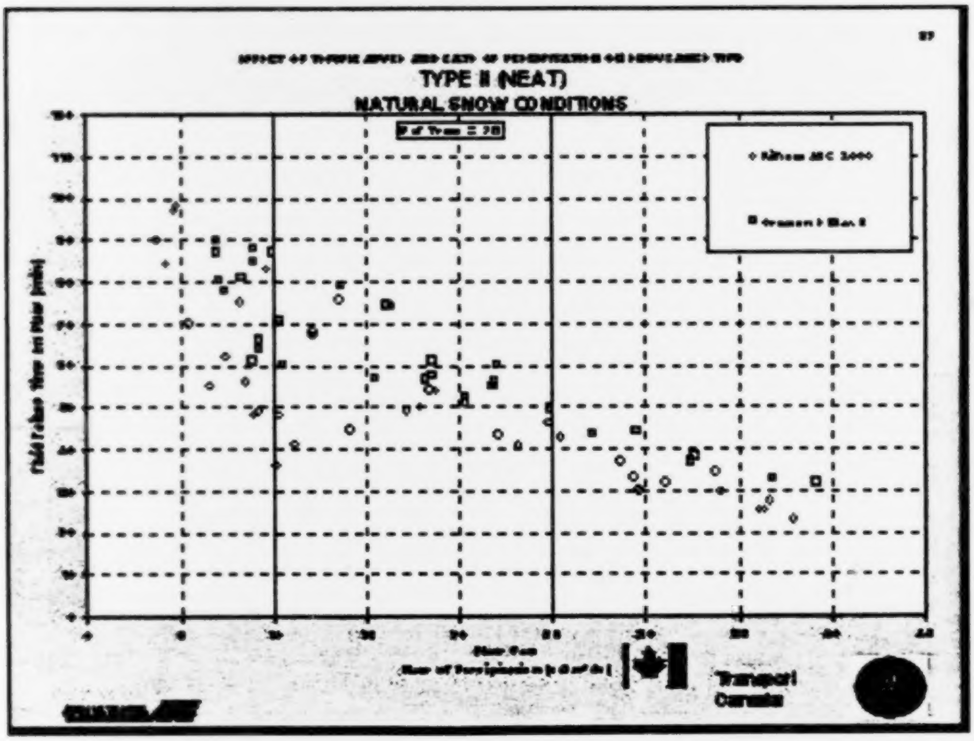
Transport
Canada

NATURAL SNOW TESTS



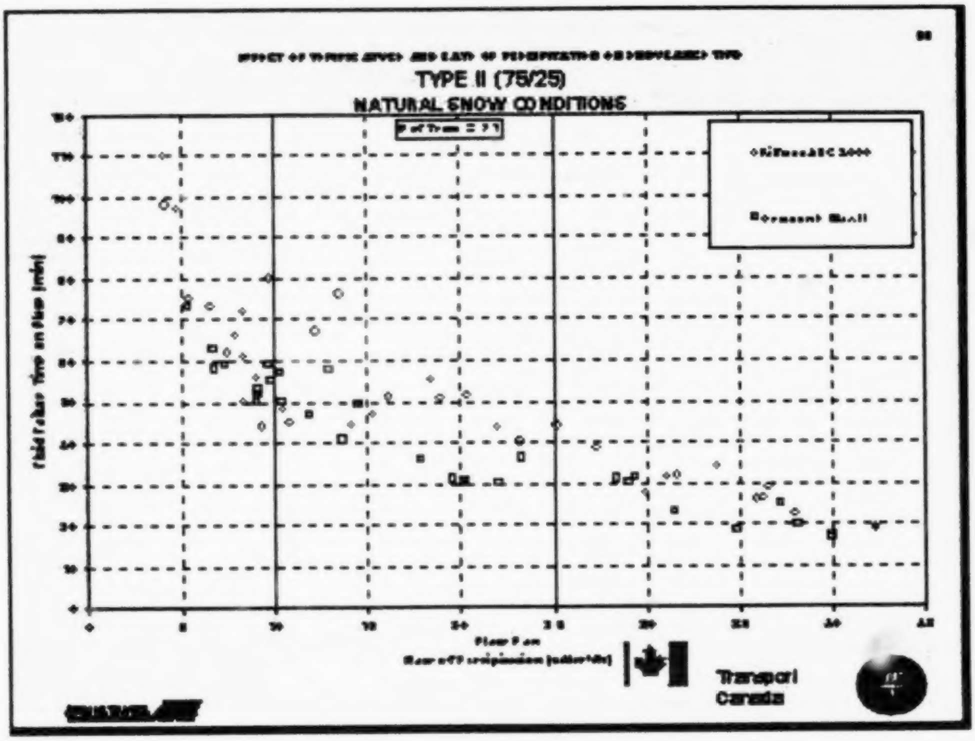
SAMPLE TYPE II NEAT
NATURAL SNOW CONDITIONS

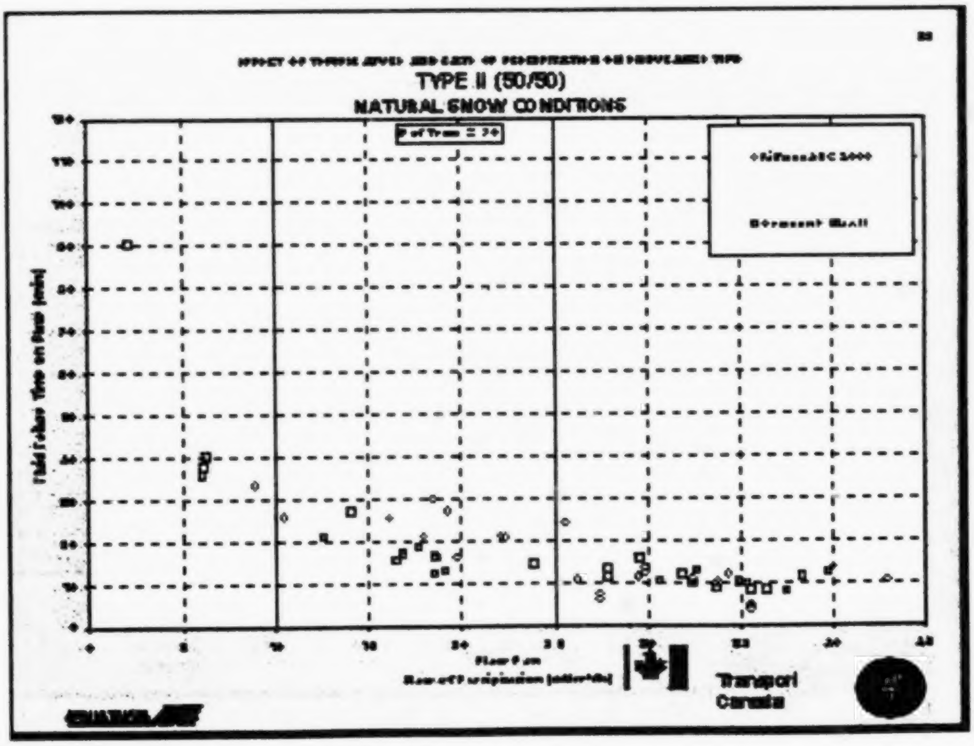
Transport Canada

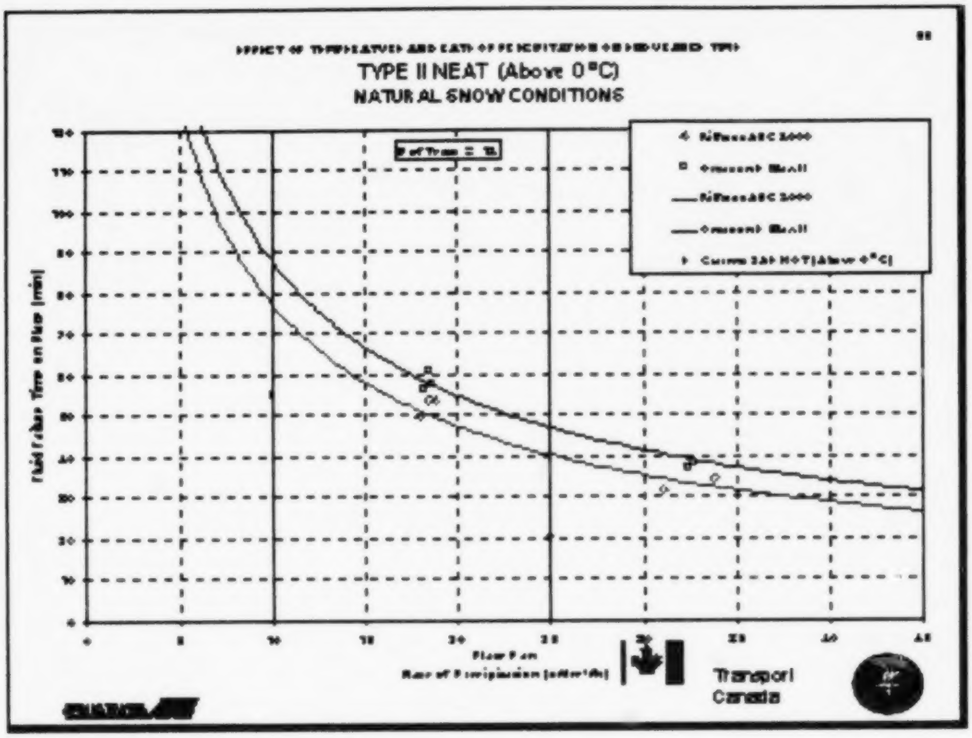


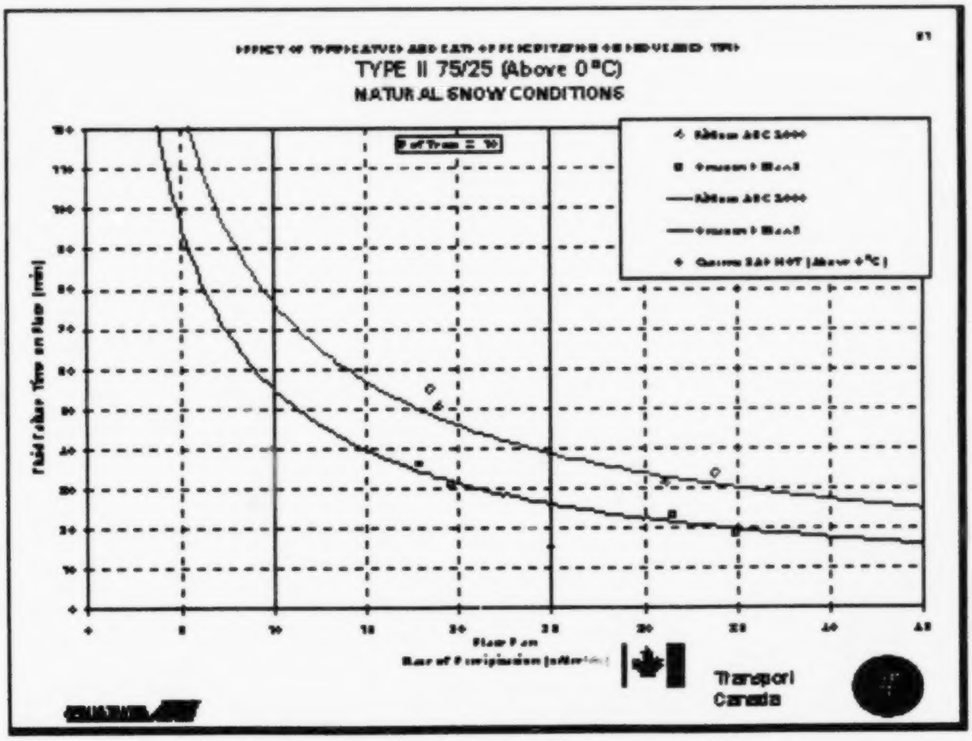
TYPE II (NEAT)
NATURAL SNOW CONDITIONS

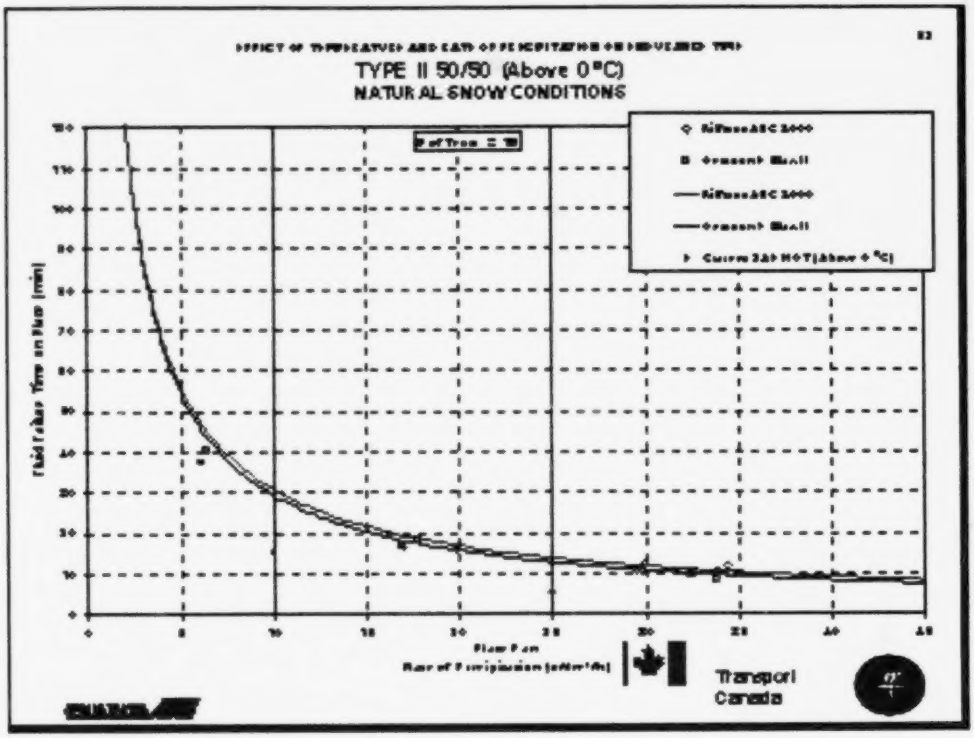
Transport Canada

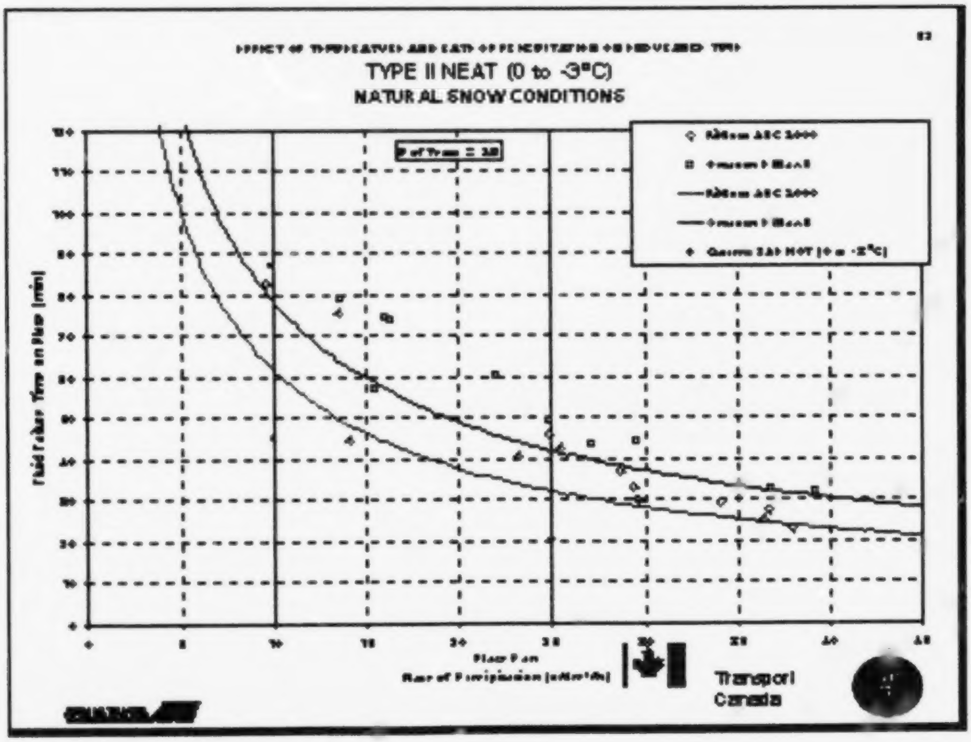

TYPE II (75/25)
NATURAL SNOW CONDITIONS
Transport Canada

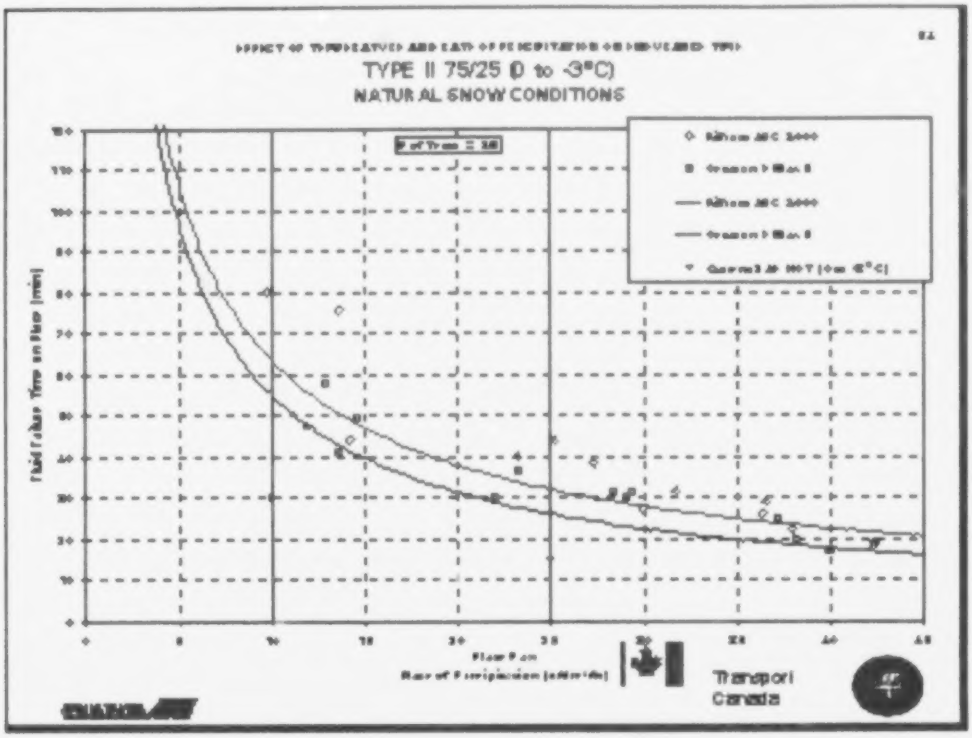

TYPE II (50/50)
NATURAL SNOW CONDITIONS
Transport Canada

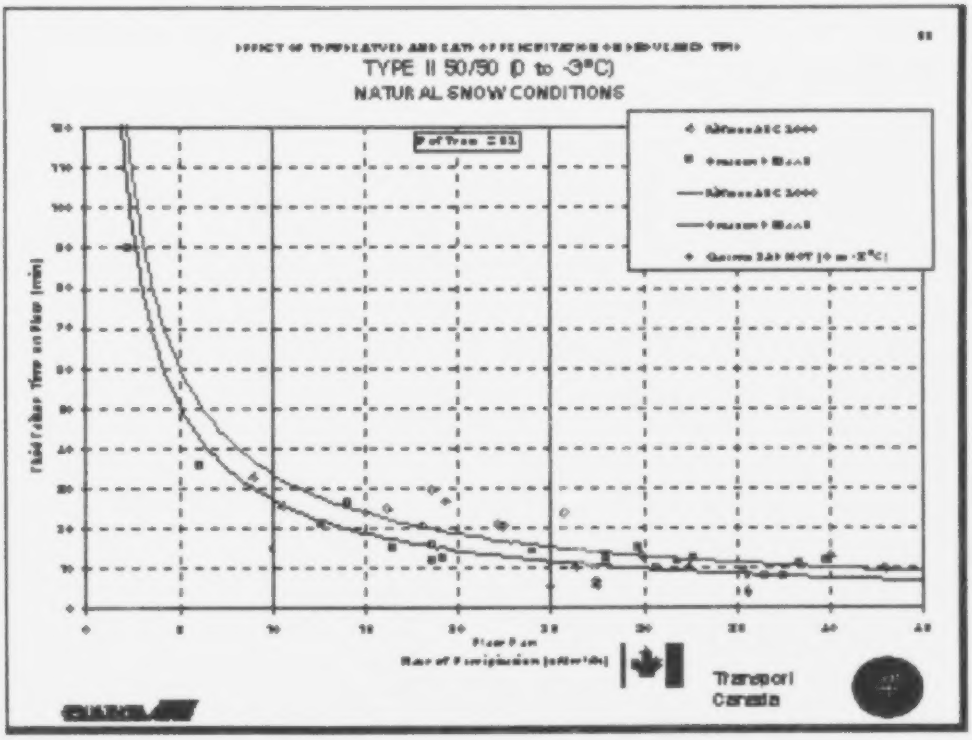

TYPE II NEAT (Above 0°C)
NATURAL SNOW CONDITIONS
120
110
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
Transport Canada

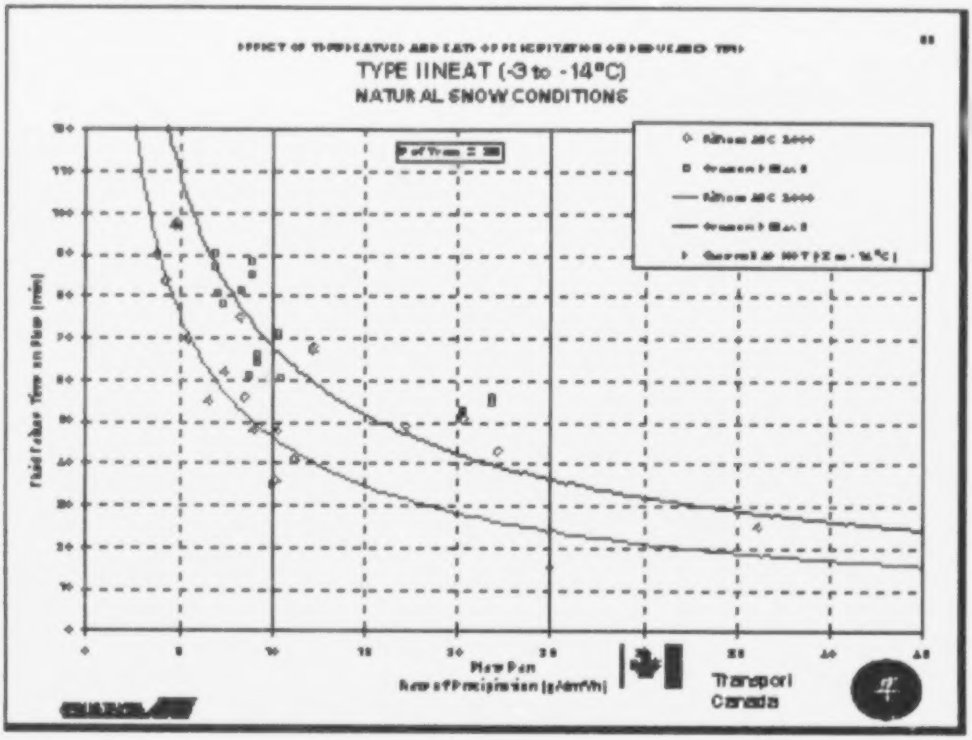

TYPE II 75/25 (Above 0°C)
NATURAL SNOW CONDITIONS
120
110
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
Transport Canada


TYPE II 50/50 (Above 0°C)
NATURAL SNOW CONDITIONS
Transport Canada


TYPE II NEAT (0 to -3°C)
NATURAL SNOW CONDITIONS
Transport Canada

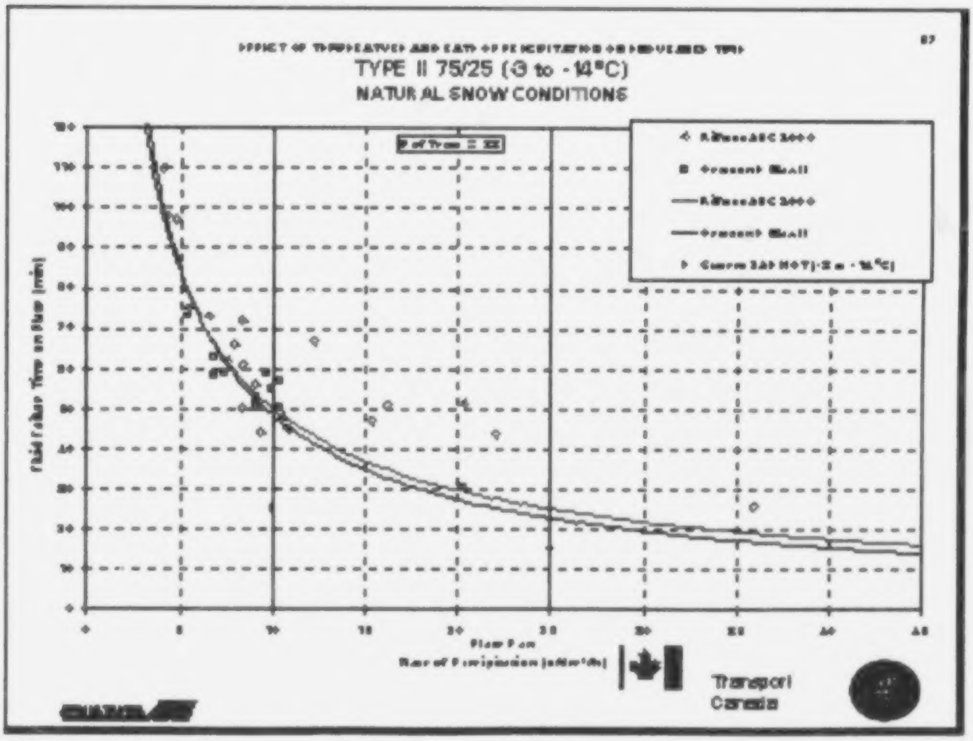

TYPE II 75/25 (0 to -3°C)
NATURAL SNOW CONDITIONS
Transport Canada


TYPE II 50/50 (0 to -3°C)
NATURAL SNOW CONDITIONS
Transport Canada



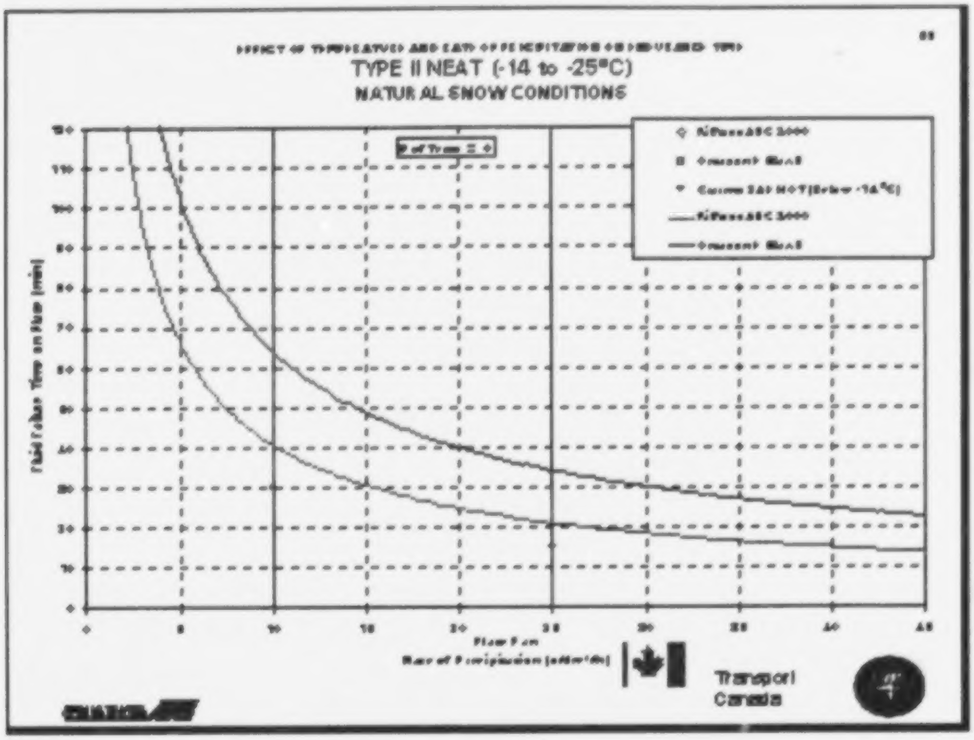
TYPE IINEAT (-3 to -14°C)

NATURAL SNOW CONDITIONS

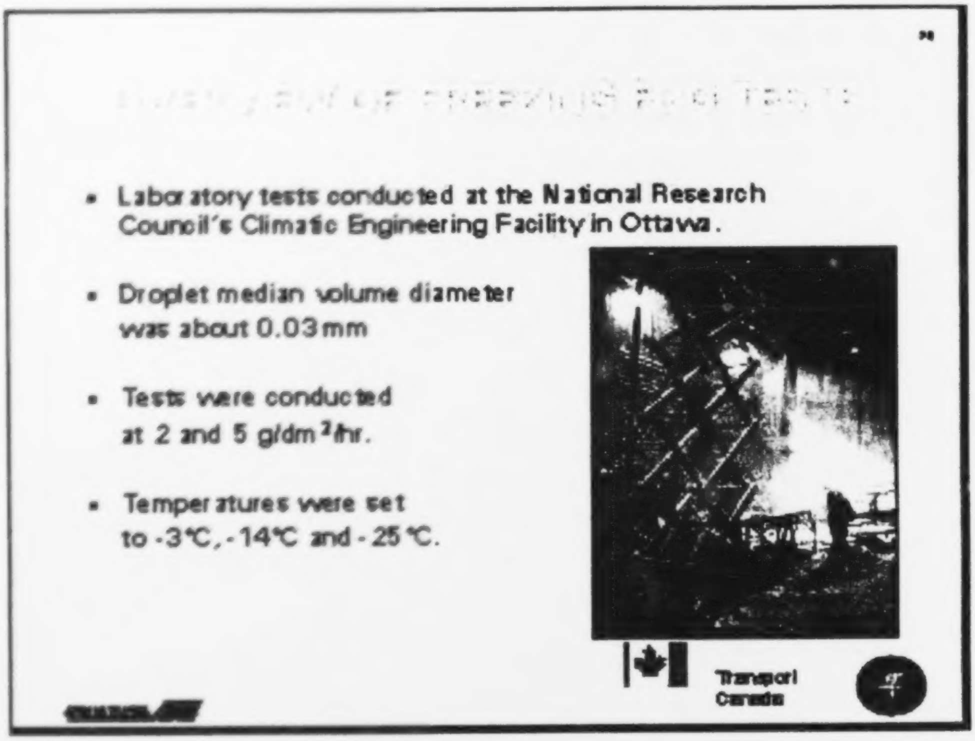


TYPE II 75/25 (-3 to -14°C)

NATURAL SNOW CONDITIONS


TYPE II NEAT (-14 to -25°C)
NATURAL SNOW CONDITIONS
120
110
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
Transport
Canada

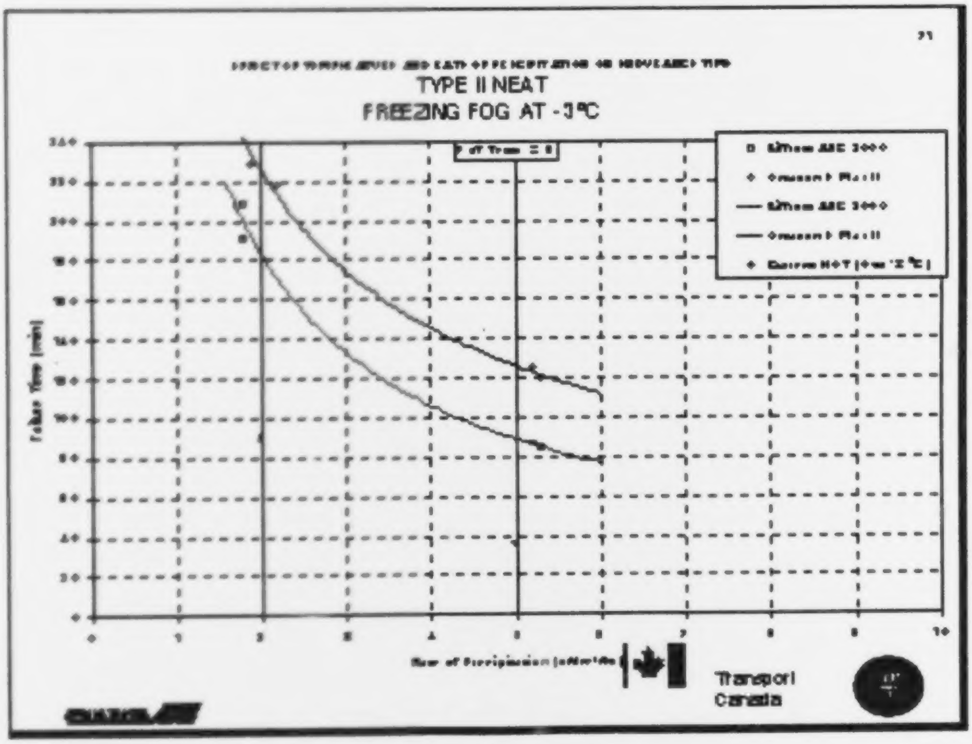
FREEZING FOG



OVERVIEW OF FREEZING FOG TESTS

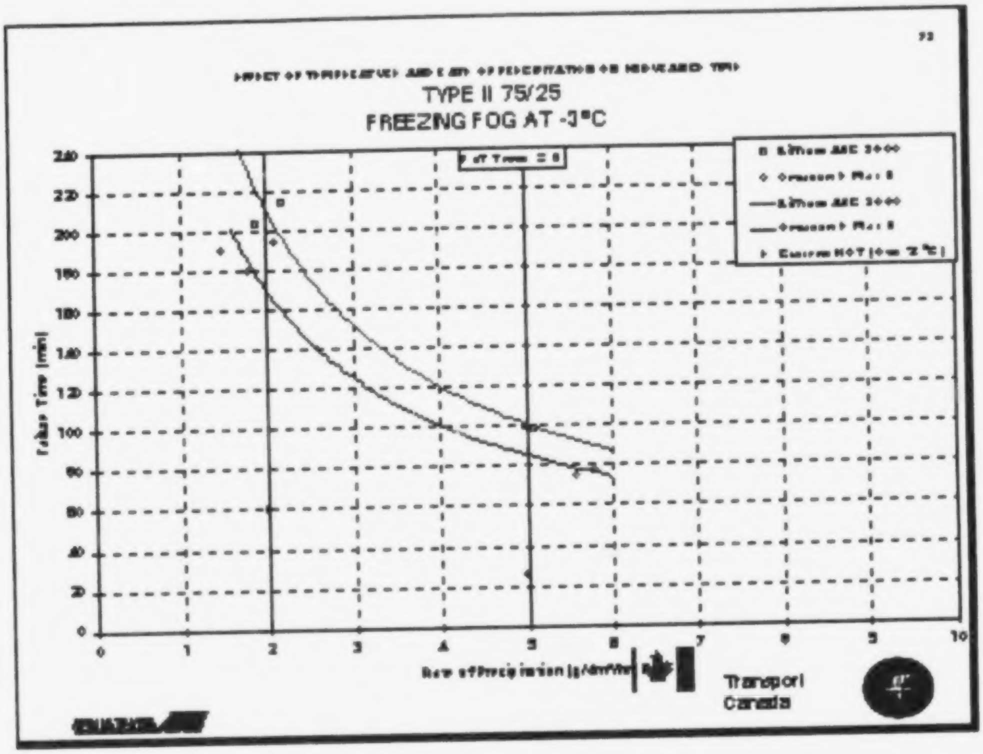
- Laboratory tests conducted at the National Research Council's Climatic Engineering Facility in Ottawa.
- Droplet median volume diameter was about 0.03 mm
- Tests were conducted at 2 and 5 g/dm²/hr.
- Temperatures were set to -3°C, -14°C and -25°C.

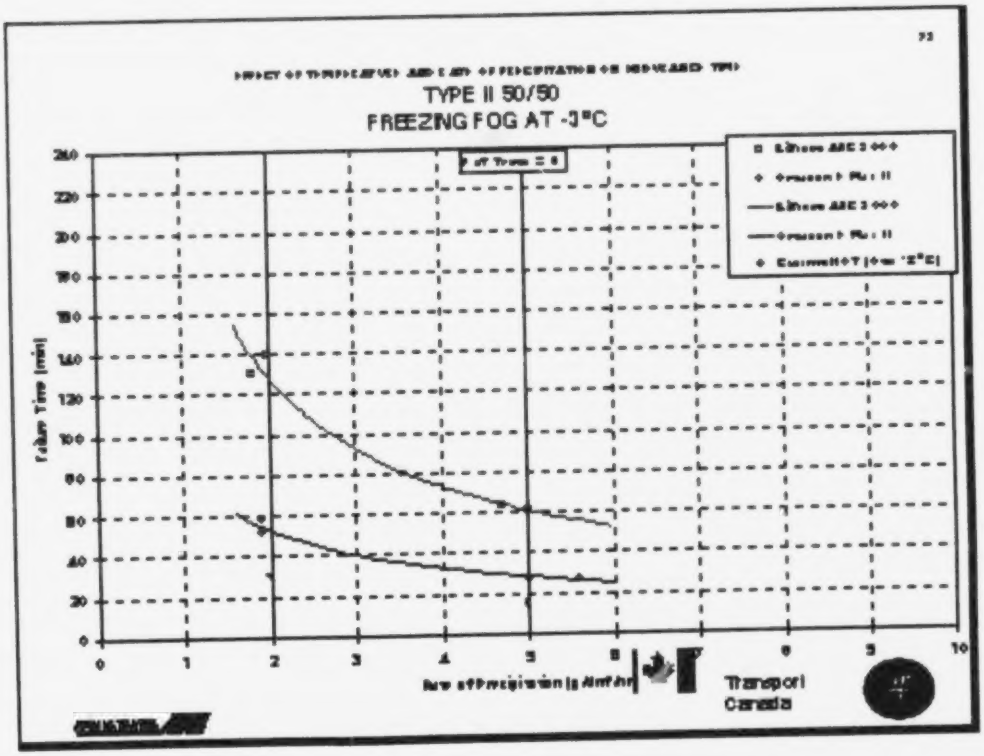
Transport Canada

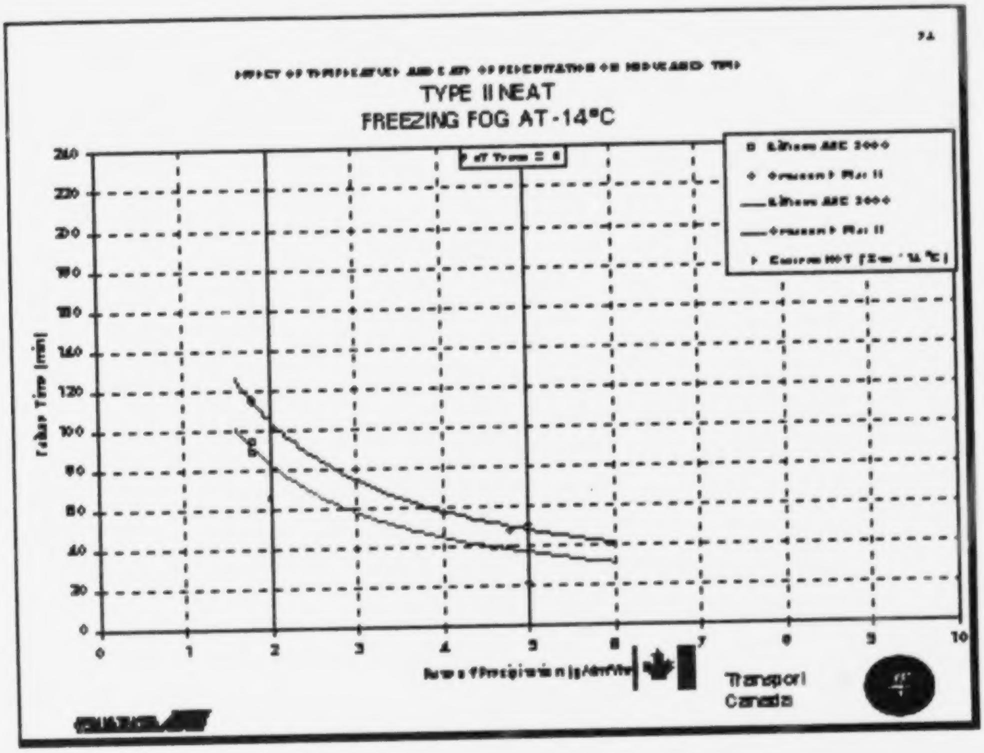


TYPE II NEAT
FREEZING FOG AT -3°C

Transport Canada


72
TYPE II 75/25
FREEZING FOG AT -3°C
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
0
1
2
3
4
5
6
7
8
9
10
Rate of Precipitation (g/dm²/h)
Transport
Canada


73
TYPE II 50/50
FREEZING FOG AT -3°C
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
0
1
2
3
4
5
6
8
9
10
Rate of Precipitation (g/dm²/h)
Transport
Canada

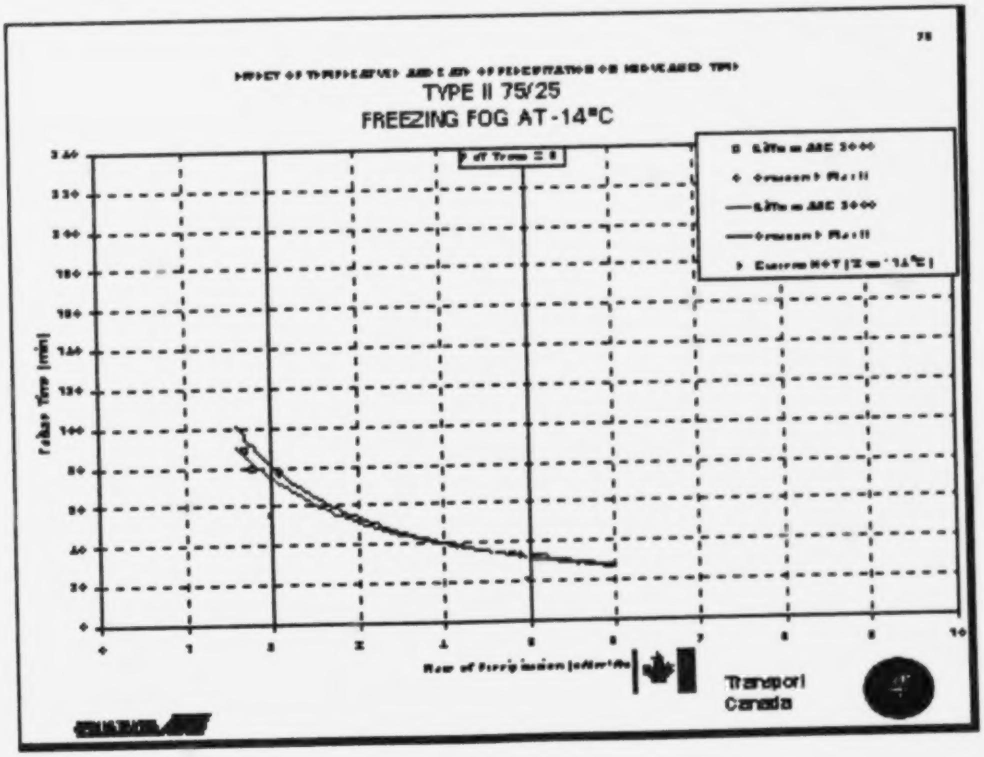


74

TYPE II NEAT

FREEZING FOG AT -14°C

Transport Canada

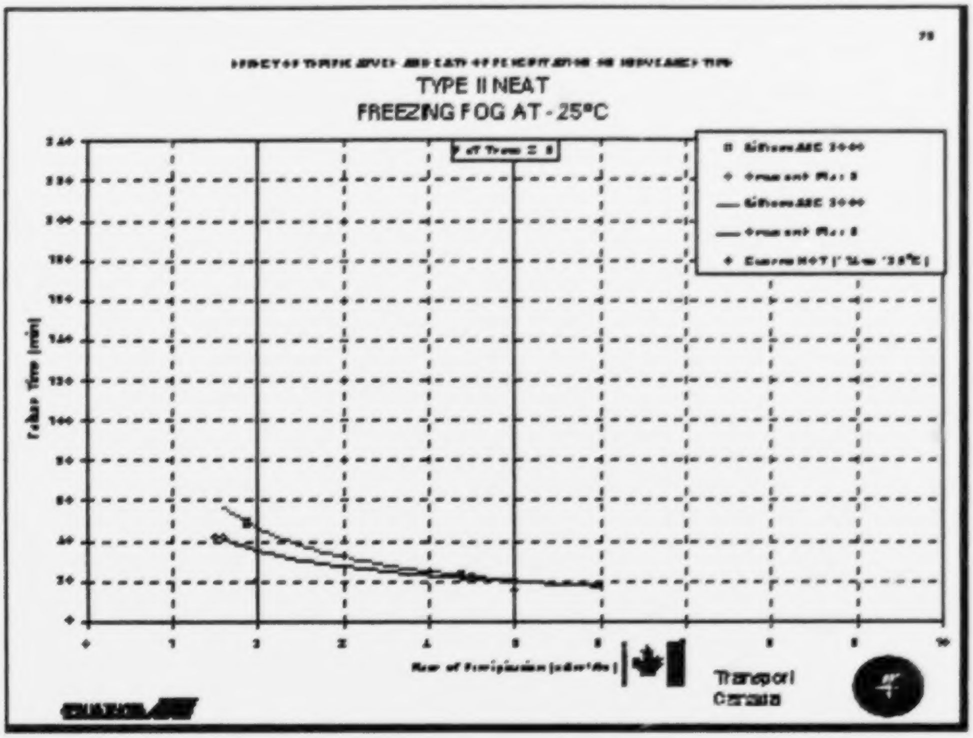


75

TYPE II 75/25

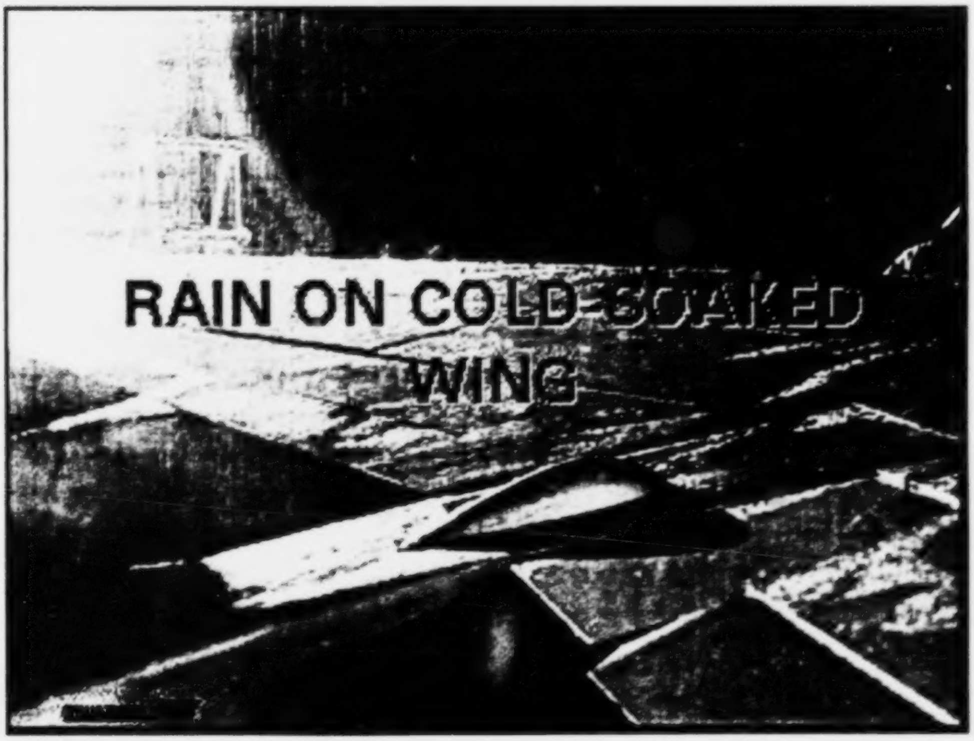
FREEZING FOG AT -14°C

Transport Canada

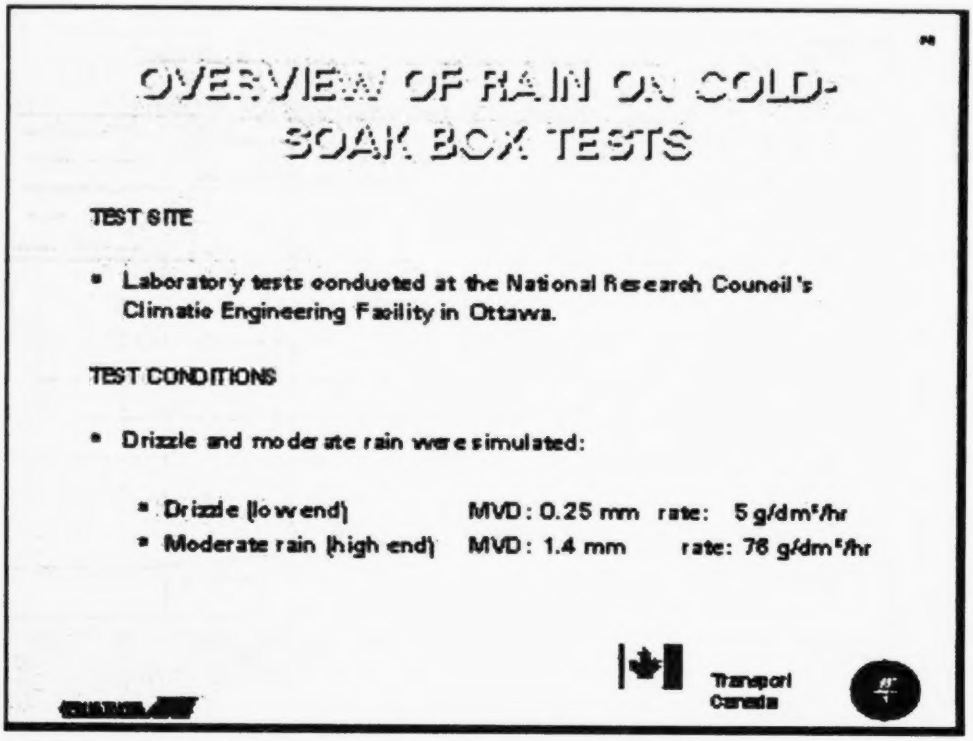


TYPE II NEAT

FREEZING FOG AT - 25°C



RAIN ON COLD-SOAKED WING



OVERVIEW OF RAIN ON COLD-SOAK BOX TESTS

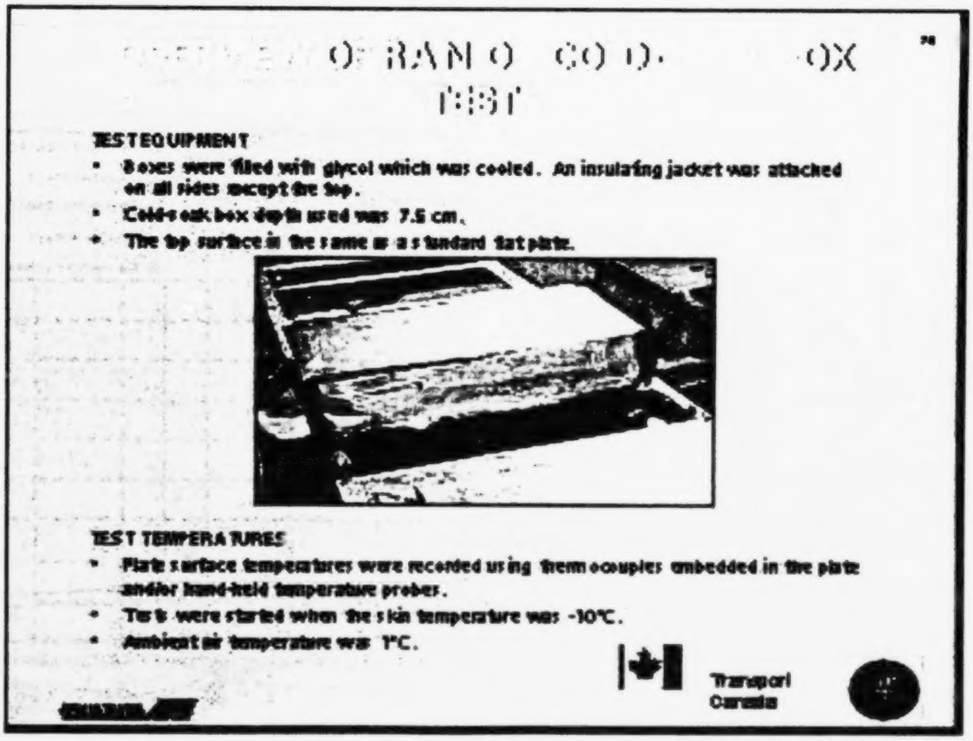
TEST SITE

- Laboratory tests conducted at the National Research Council's Climatic Engineering Facility in Ottawa.

TEST CONDITIONS

- Drizzle and moderate rain were simulated:
  - Drizzle (low end) MVD: 0.25 mm rate: 5 g/dm²/hr
  - Moderate rain (high end) MVD: 1.4 mm rate: 76 g/dm²/hr

Transport Canada



OVERVIEW OF RAIN ON COLD-SOAK BOX TEST

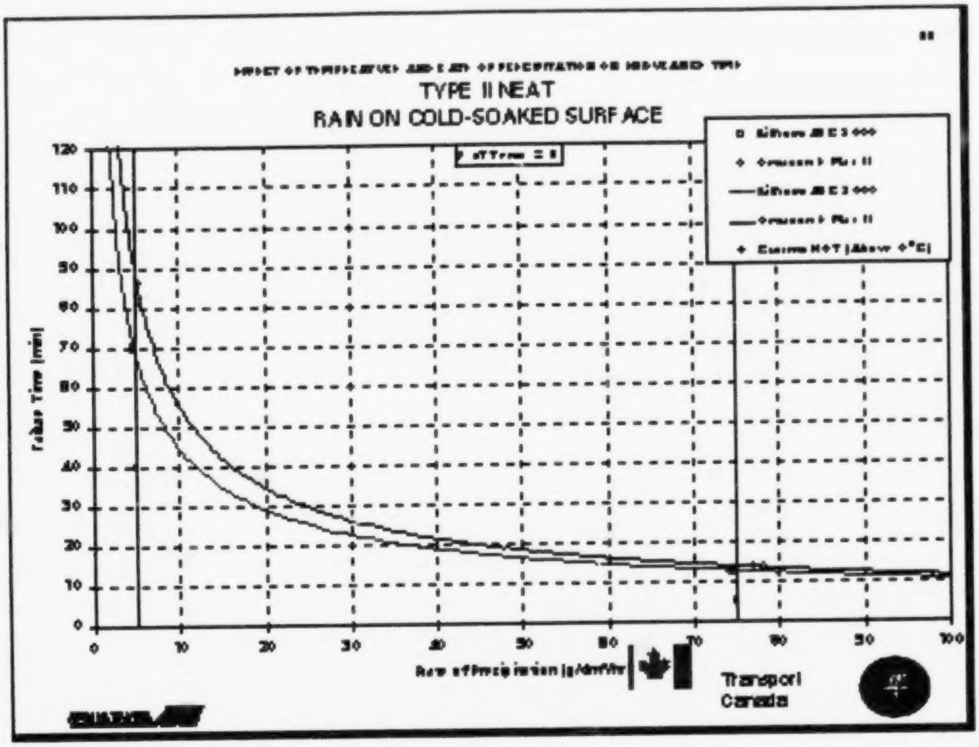
TEST EQUIPMENT

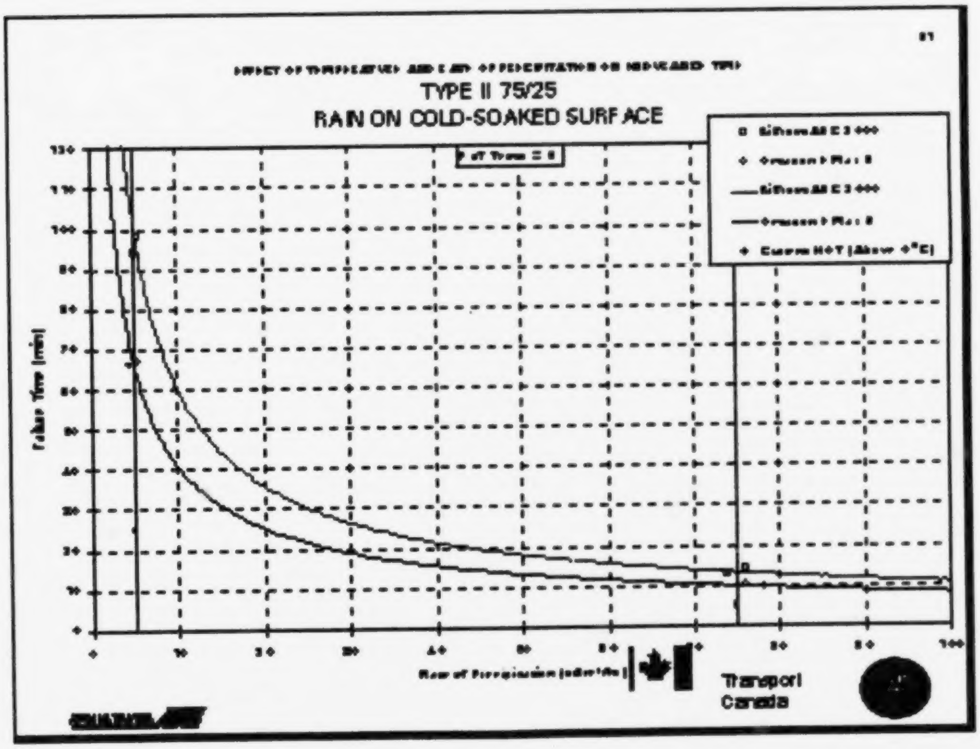
- Boxes were filled with glycol which was cooled. An insulating jacket was attached on all sides except the top.
- Cold-soak box depth used was 7.5 cm.
- The top surface is the same as a standard flat plate.

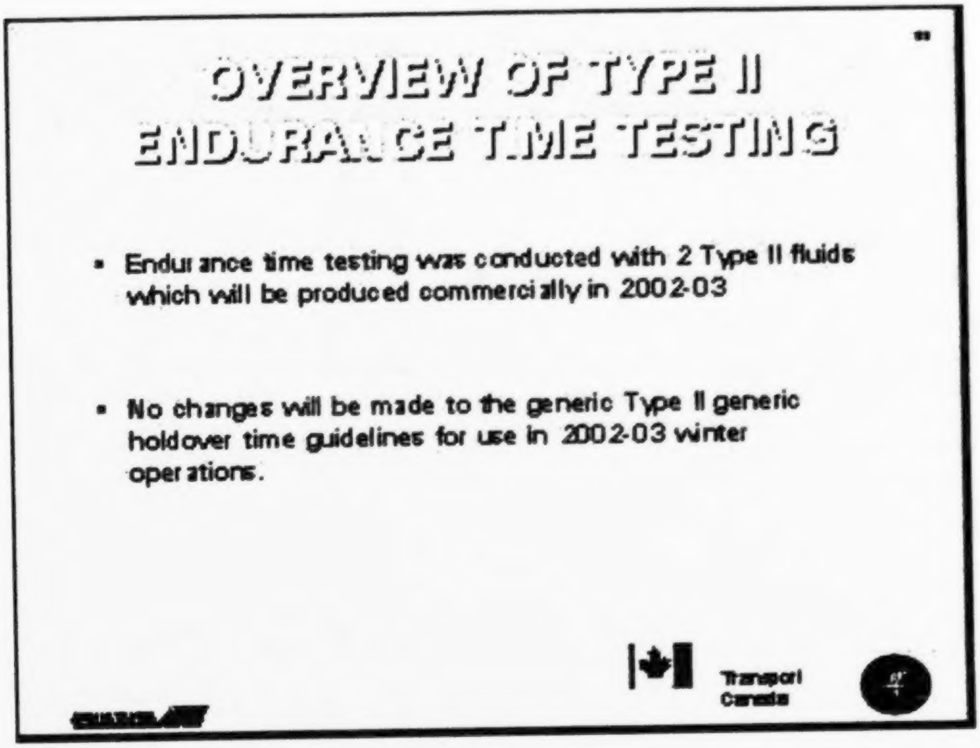
TEST TEMPERATURES

- Plate surface temperatures were recorded using thermocouples embedded in the plate and/or hand-held temperature probes.
- Tests were started when the skin temperature was -10°C.
- Ambient air temperature was 1°C.

Transport Canada


TYPE II NEAT
RAIN ON COLD-SOAKED SURFACE
120
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Transport
Canada

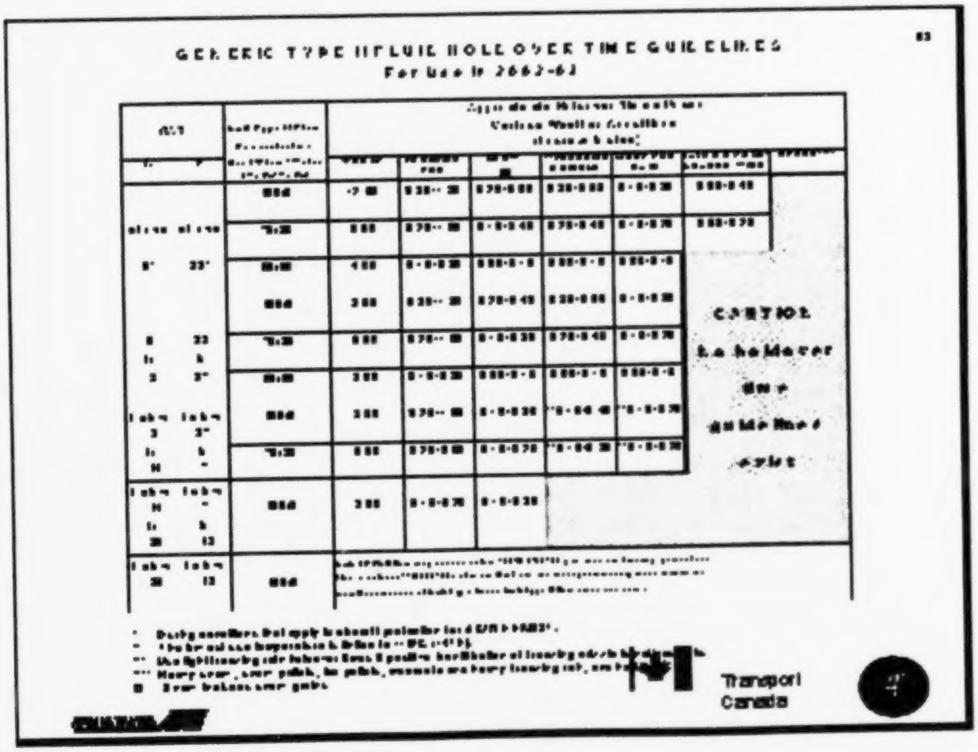

81
TYPE II 75/25
RAIN ON COLD-SOAKED SURFACE
Transport
Canada



OVERVIEW OF TYPE II ENDURANCE TIME TESTING

- Endurance time testing was conducted with 2 Type II fluids which will be produced commercially in 2002-03
- No changes will be made to the generic Type II generic holdover time guidelines for use in 2002-03 winter operations.

Transport Canada



GENERIC TYPE II FLUID HOLDOVER TIME GUIDELINES

For Use in 2002-03

CAUTION

No holdover time guidelines exist

Transport Canada

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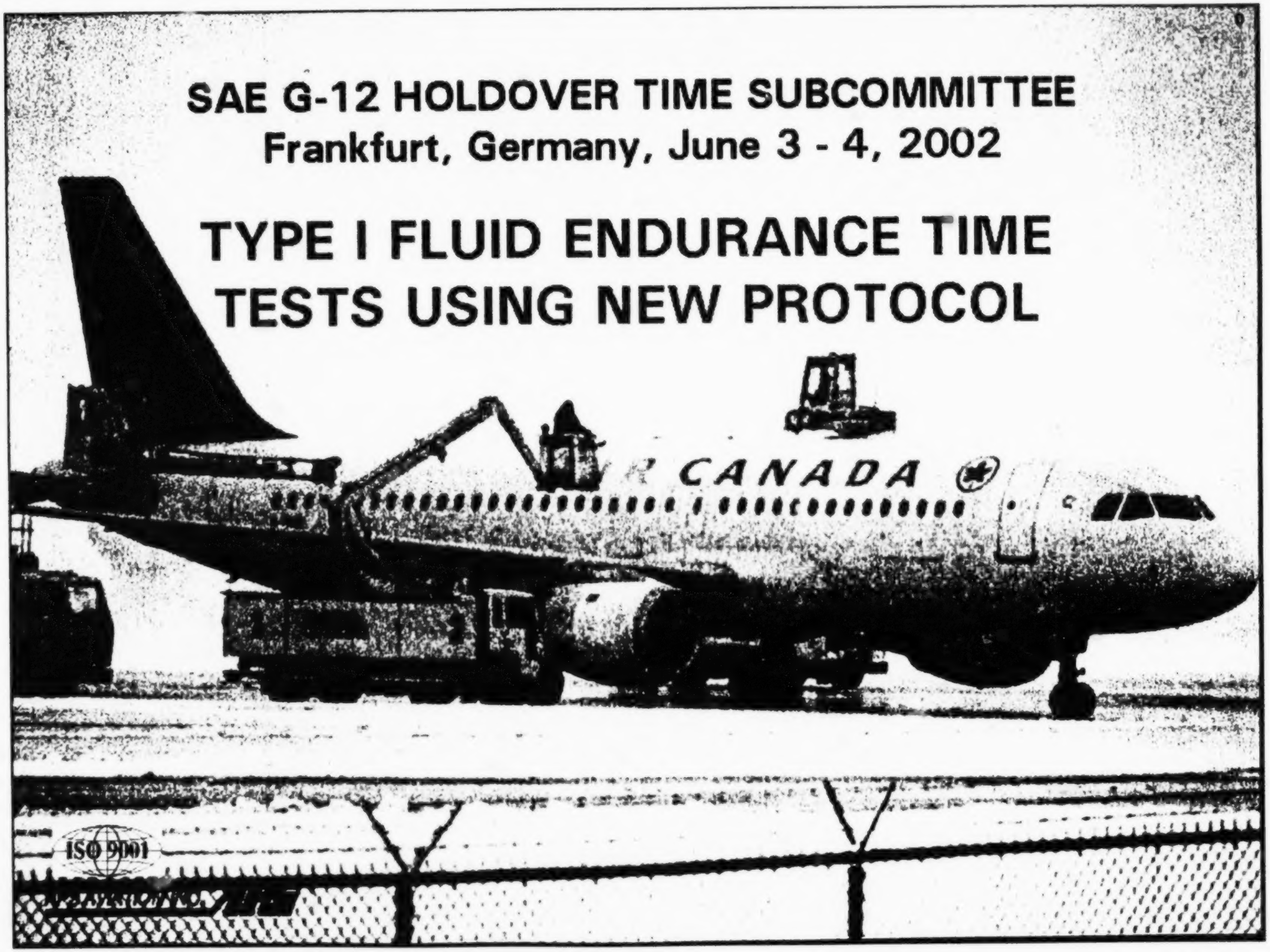

SAE G-12 HOLDOVER TIME SUBCOMMITTEE
Frankfurt, Germany, June 3 - 4, 2002

TYPE I FLUID ENDURANCE TIME
TESTS USING NEW PROTOCOL

CANADA
ISO 9001

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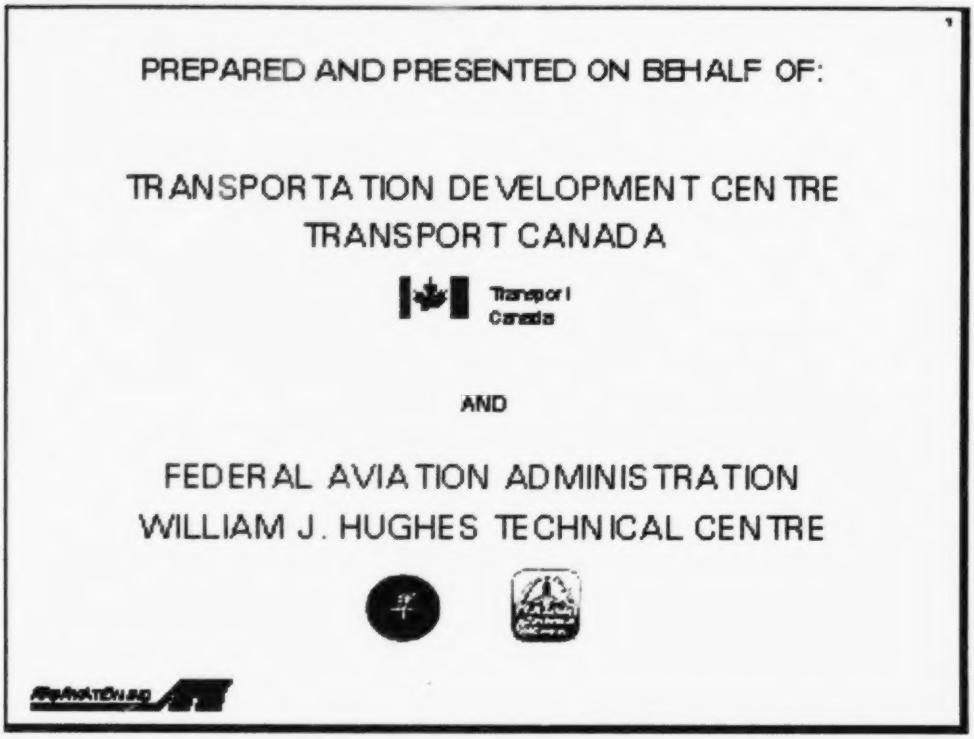


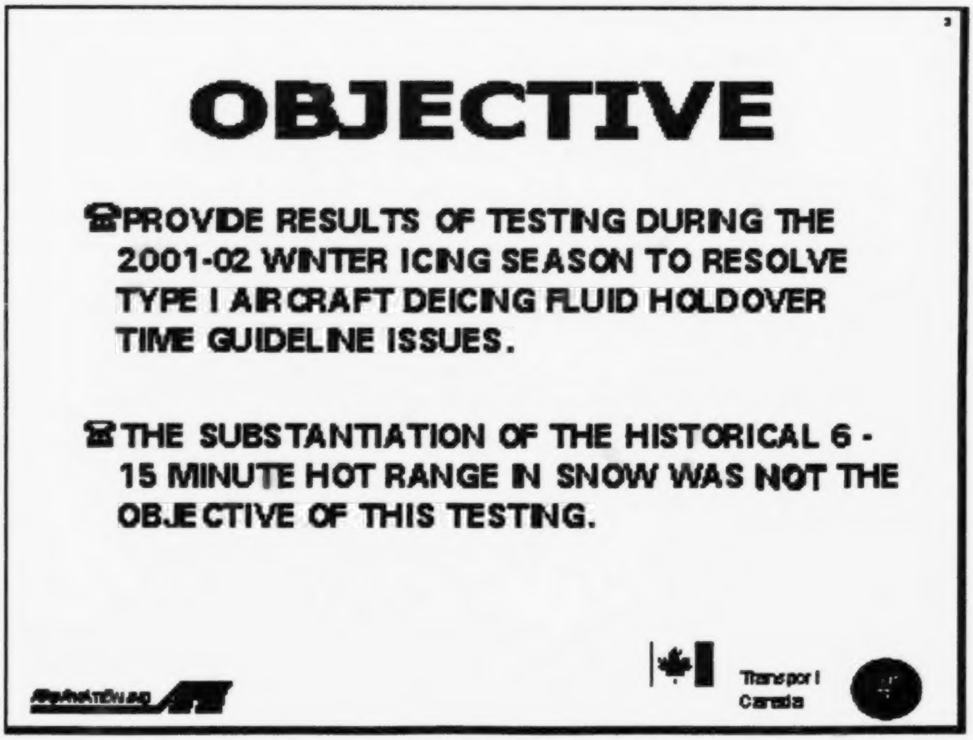
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

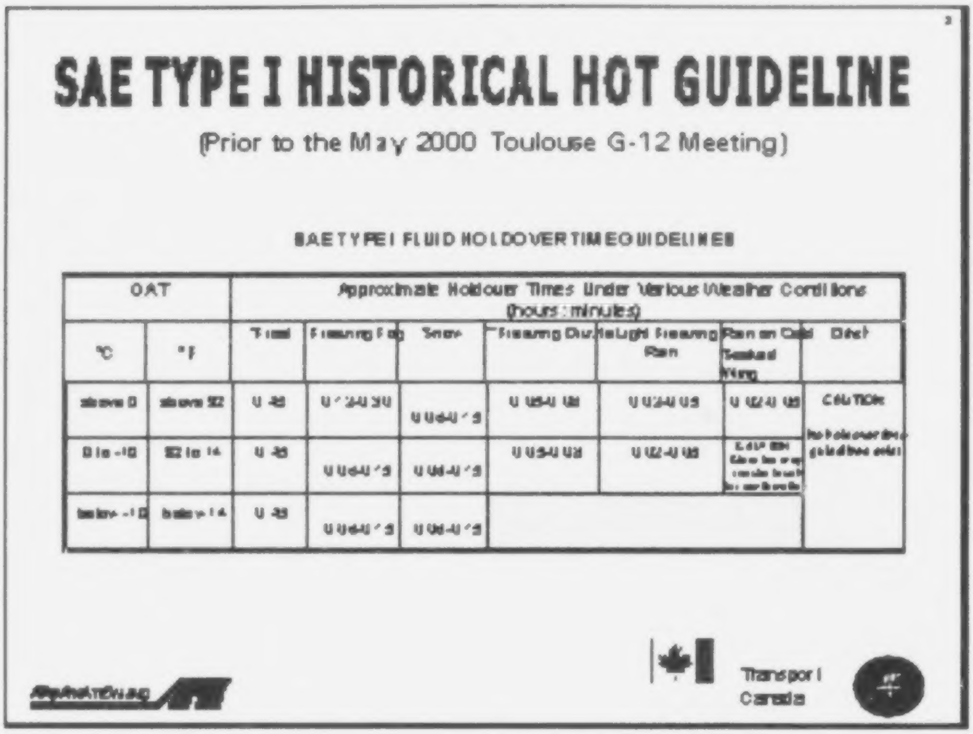
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OBJECTIVE

- ☎PROVIDE RESULTS OF TESTING DURING THE 2001-02 WINTER ICING SEASON TO RESOLVE TYPE I AIRCRAFT DEICING FLUID HOLDOVER TIME GUIDELINE ISSUES.
- ☎THE SUBSTANTIATION OF THE HISTORICAL 6 - 15 MINUTE HOT RANGE IN SNOW WAS NOT THE OBJECTIVE OF THIS TESTING.

Transport Canada



3

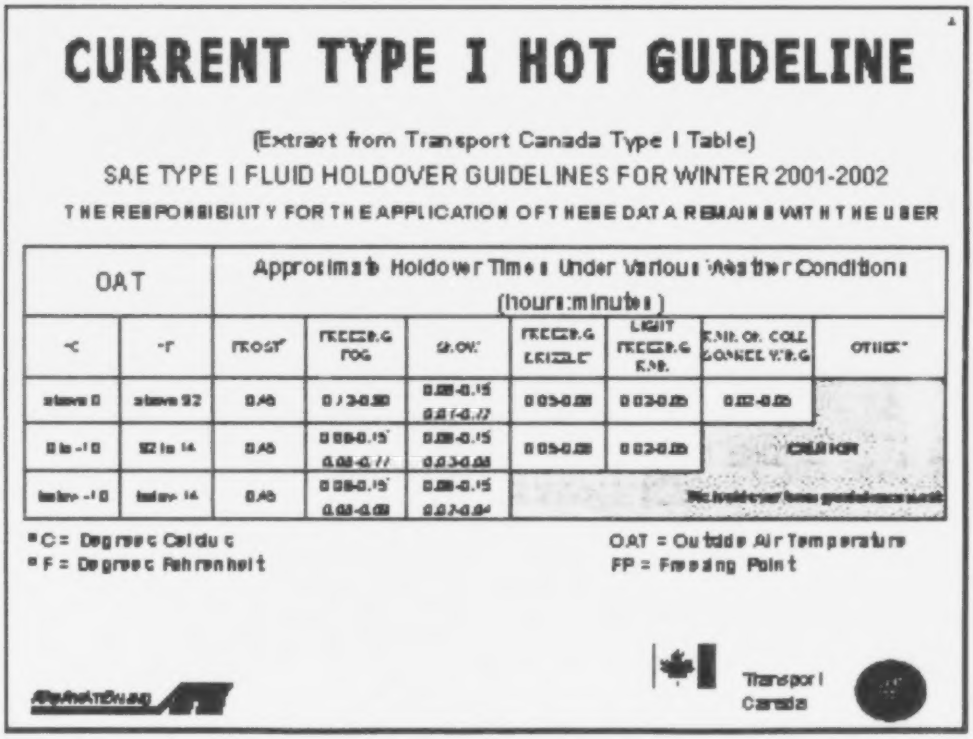
SAE TYPE I HISTORICAL HOT GUIDELINE

(Prior to the May 2000 Toulouse G-12 Meeting)

SAE TYPE I FLUID HOLDOVER TIME GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Frost	Freezing Fog	Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
above 0	above 32	0:45	0:12-0:30	0:06-0:15	0:05-0:08	0:02-0:05	0:02-0:05	CAUTION No holdover time guidelines exist
0 to -10	32 to 14	0:45	0:06-0:15	0:06-0:15	0:05-0:08	0:02-0:05	CAUTION Clear ice may require touch for confirmation	
below -10	below 14	0:45	0:06-0:15	0:06-0:15				

Transport Canada



4

CURRENT TYPE I HOT GUIDELINE

(Extract from Transport Canada Type I Table)

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002

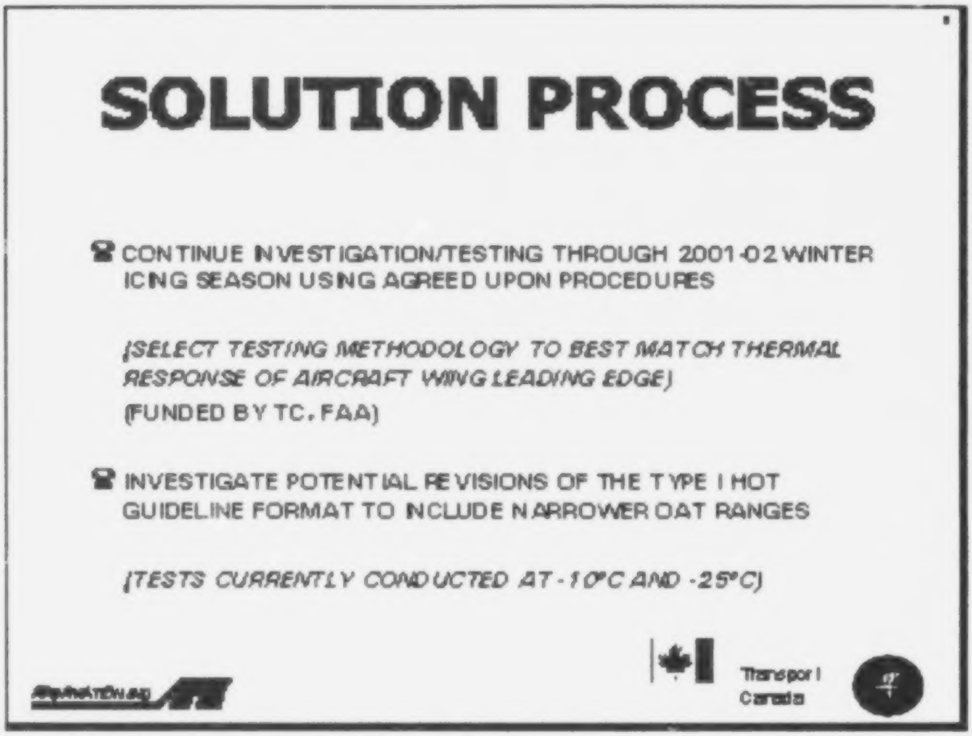
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST*	FREEZING FOG	SNOW	FREEZING DRIZZLE*	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER**
above 0	above 32	0:45	0:12-0:30	0:06-0:15 0:11-0:22	0:05-0:08	0:02-0:05	0:02-0:05	
0 to -10	32 to 14	0:45	0:06-0:15 0:08-0:17	0:06-0:15 0:03-0:08	0:05-0:08	0:02-0:05	CAUTION	
below -10	below 14	0:45	0:06-0:15 0:03-0:08	0:06-0:15 0:02-0:04			No holdover time guidelines exist	

°C = Degrees Celsius
°F = Degrees Fahrenheit

OAT = Outside Air Temperature
FP = Freezing Point

Transport Canada



SOLUTION PROCESS

- CONTINUE INVESTIGATION/TESTING THROUGH 2001-02 WINTER ICING SEASON USING AGREED UPON PROCEDURES

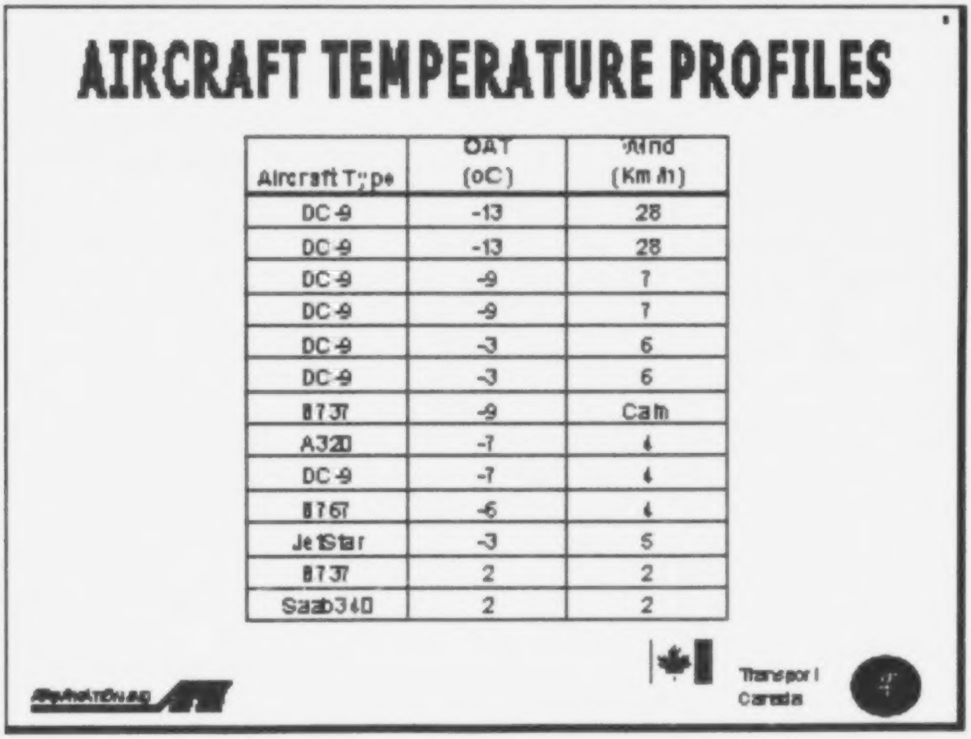
  (SELECT TESTING METHODOLOGY TO BEST MATCH THERMAL RESPONSE OF AIRCRAFT WING LEADING EDGE)

  (FUNDED BY TC, FAA)

- INVESTIGATE POTENTIAL REVISIONS OF THE TYPE I HOT GUIDELINE FORMAT TO INCLUDE NARROWER OAT RANGES

  (TESTS CURRENTLY CONDUCTED AT -10°C AND -25°C)

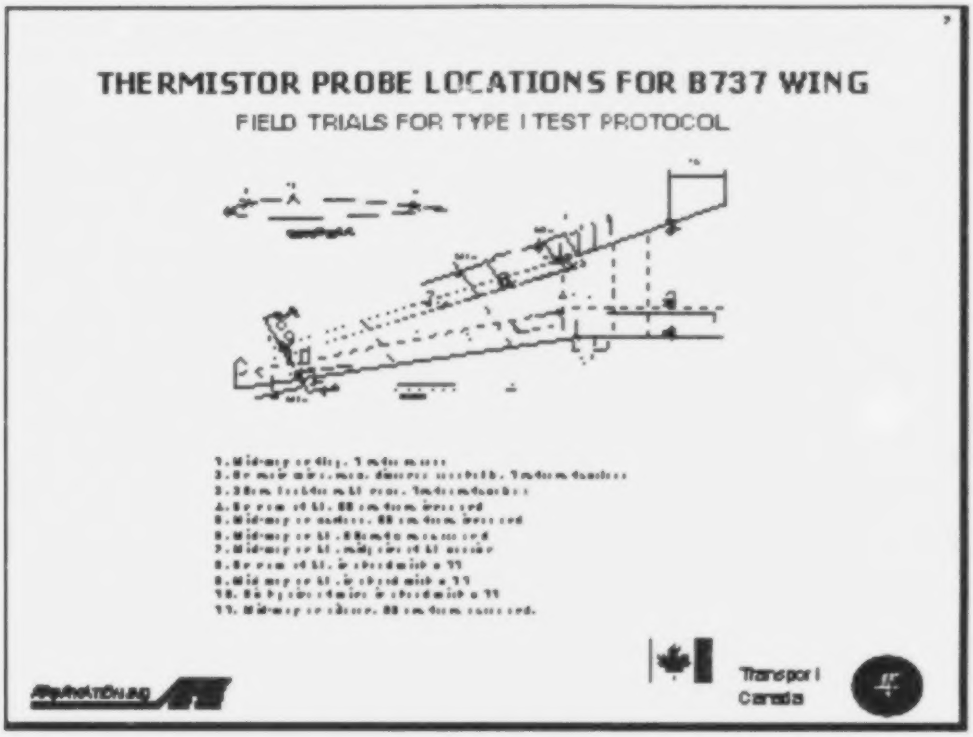
Transport Canada



AIRCRAFT TEMPERATURE PROFILES

Aircraft Type	OAT (oC)	Wind (Km/h)
DC-9	-13	28
DC-9	-13	28
DC-9	-9	7
DC-9	-9	7
DC-9	-3	6
DC-9	-3	6
B737	-9	Calm
A320	-7	4
DC-9	-7	4
B767	-6	4
JetStar	-3	5
B737	2	2
Saab340	2	2

Transport Canada



THERMISTOR PROBE LOCATIONS FOR B737 WING

FIELD TRIALS FOR TYPE I TEST PROTOCOL

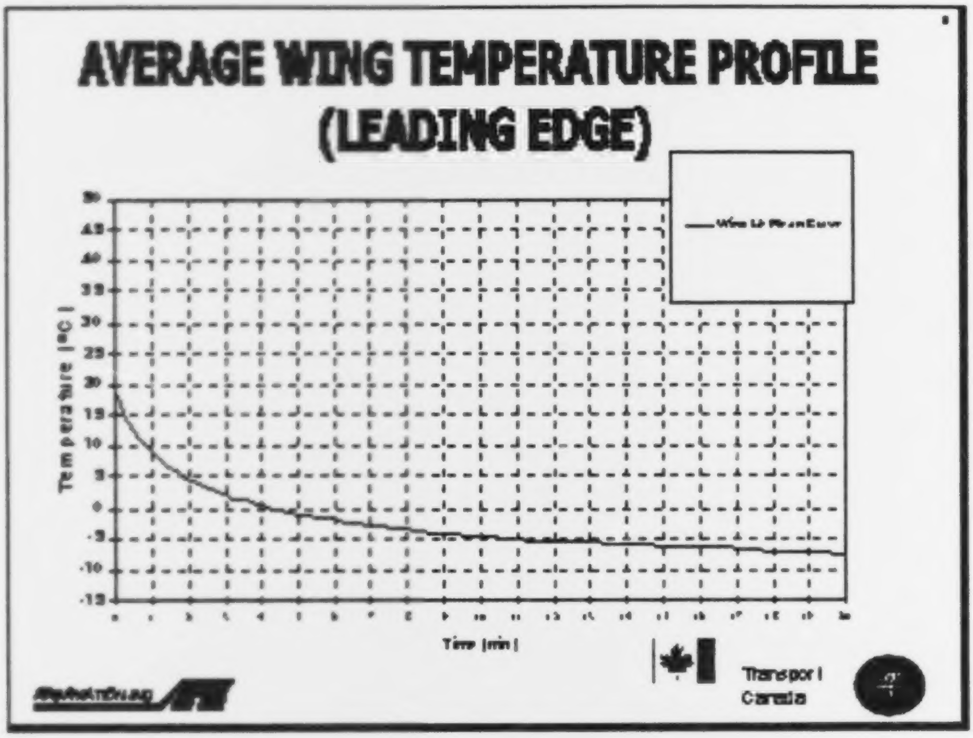
Transport Canada

FIELD TRIALS FOR TYPE I TEST PROTOCOL

THERMISTORS ON SAAB 340

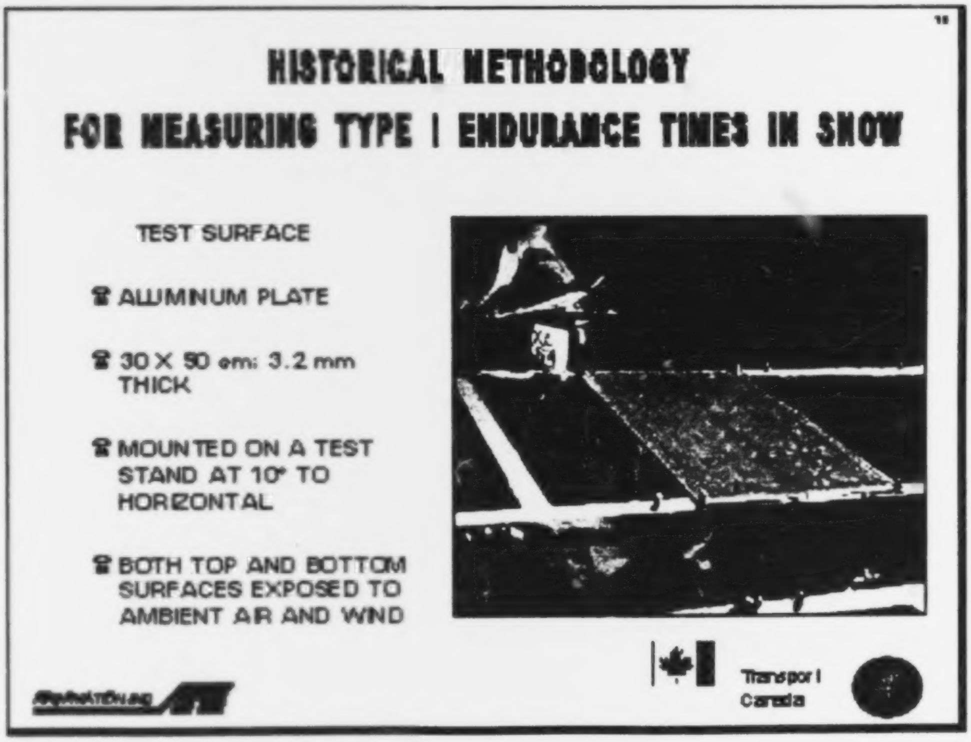
DC-9 SPRAY APPLICATION

Transport Canada



AVERAGE WING TEMPERATURE PROFILE (LEADING EDGE)

Transport Canada

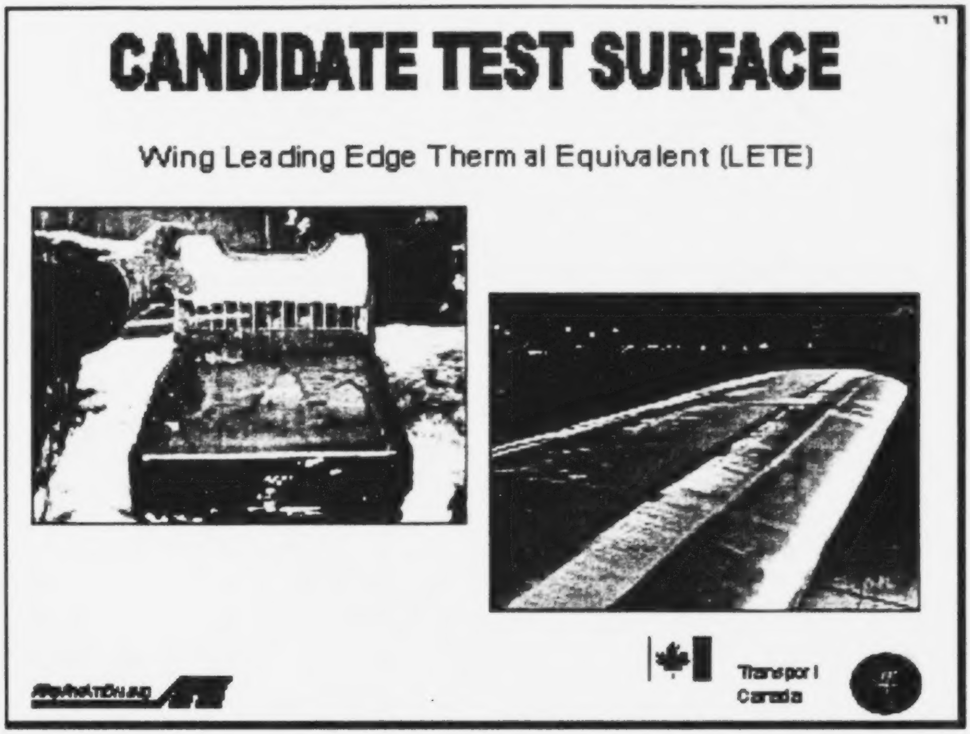


HISTORICAL METHODOLOGY FOR MEASURING TYPE I ENDURANCE TIMES IN SNOW

TEST SURFACE

- ALUMINUM PLATE
- 30 X 50 cm; 3.2 mm THICK
- MOUNTED ON A TEST STAND AT 10° TO HORIZONTAL
- BOTH TOP AND BOTTOM SURFACES EXPOSED TO AMBIENT AIR AND WIND

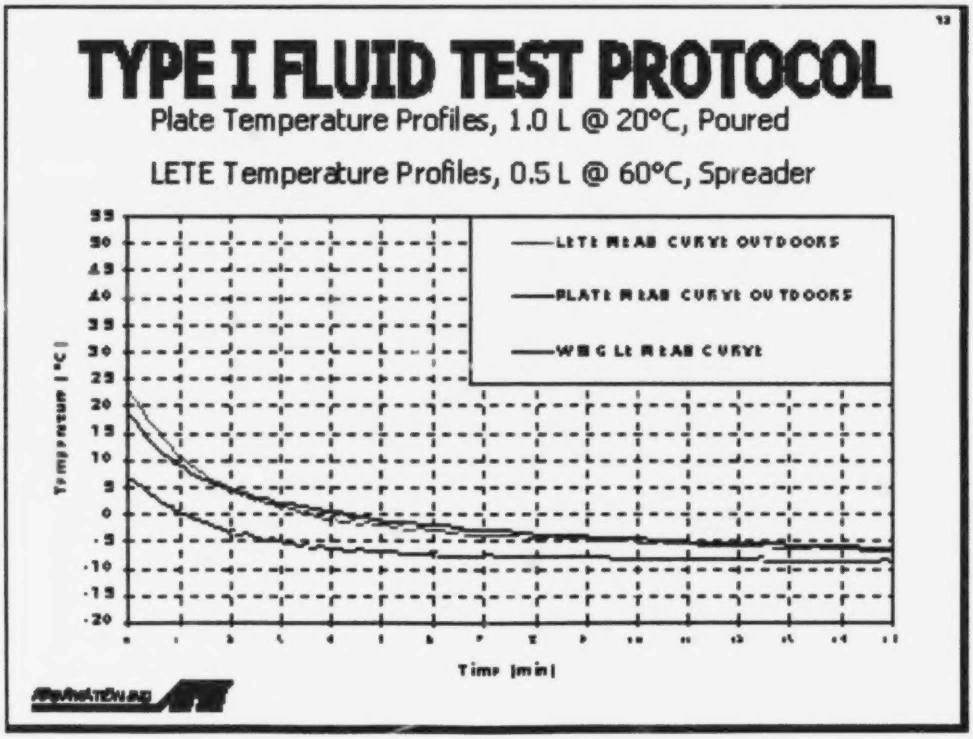
Transport Canada



CANDIDATE TEST SURFACE

Wing Leading Edge Thermal Equivalent (LETE)

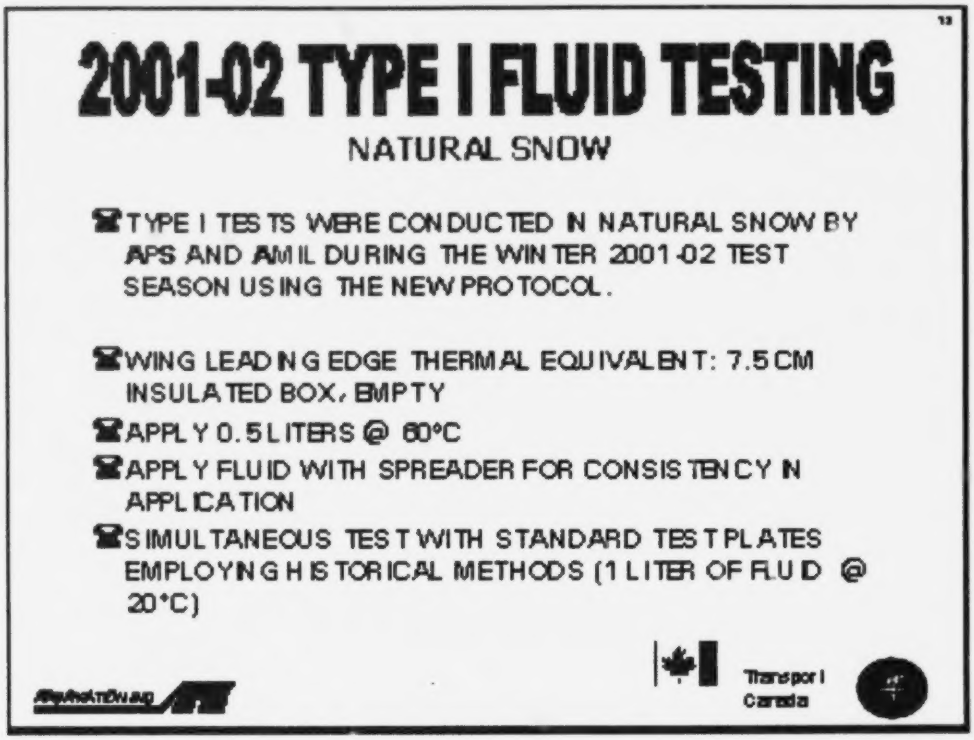
Transport Canada



TYPE I FLUID TEST PROTOCOL

Plate Temperature Profiles, 1.0 L @ 20°C, Poured

LETE Temperature Profiles, 0.5 L @ 60°C, Spreader



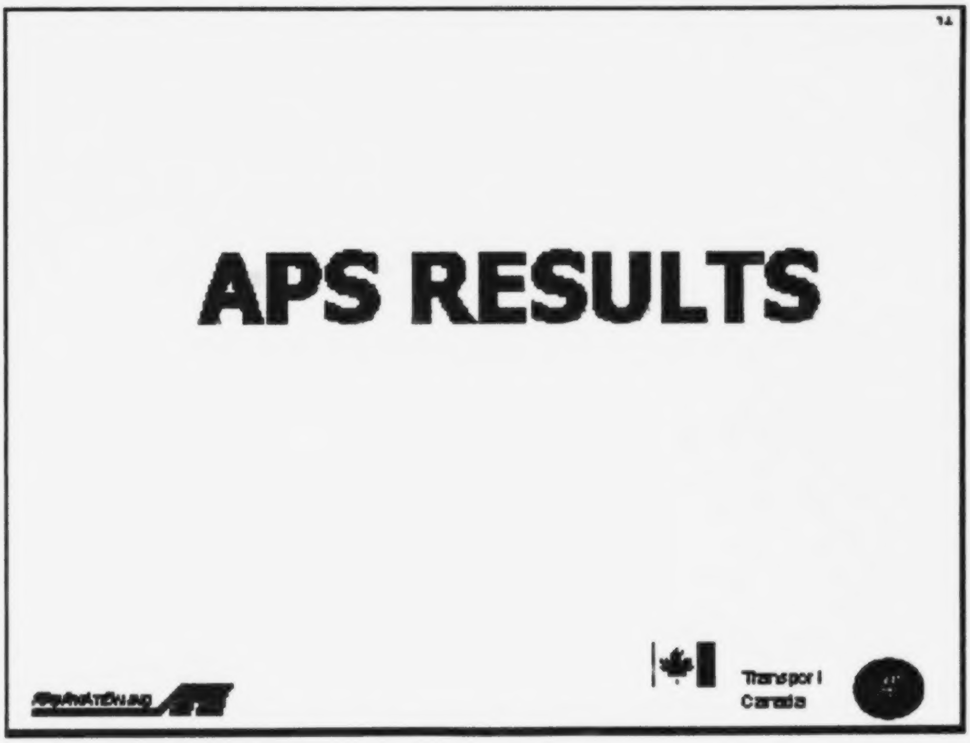
2001-02 TYPE I FLUID TESTING

NATURAL SNOW

- ☎ TYPE I TESTS WERE CONDUCTED IN NATURAL SNOW BY APS AND AMIL DURING THE WINTER 2001-02 TEST SEASON USING THE NEW PROTOCOL.

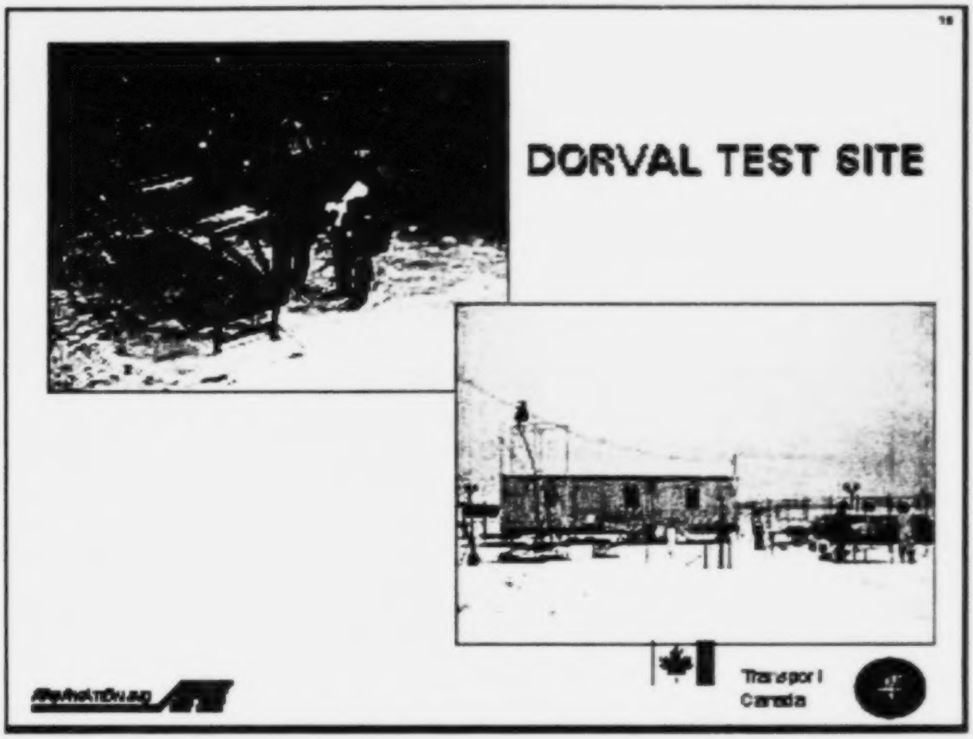
- ☎ WING LEADING EDGE THERMAL EQUIVALENT: 7.5 CM INSULATED BOX, EMPTY
- ☎ APPLY 0.5 LITERS @ 60°C
- ☎ APPLY FLUID WITH SPREADER FOR CONSISTENCY IN APPLICATION
- ☎ SIMULTANEOUS TEST WITH STANDARD TEST PLATES EMPLOYING HISTORICAL METHODS (1 LITER OF FLUID @ 20°C)

Transport Canada



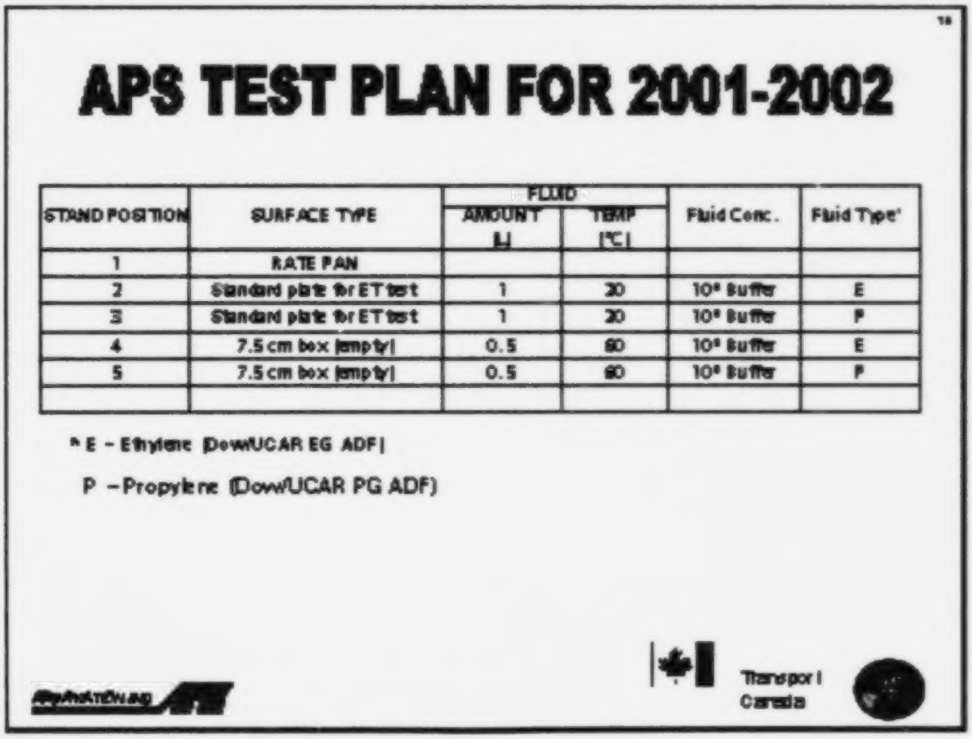
APS RESULTS

Transport Canada



DORVAL TEST SITE

Transport Canada



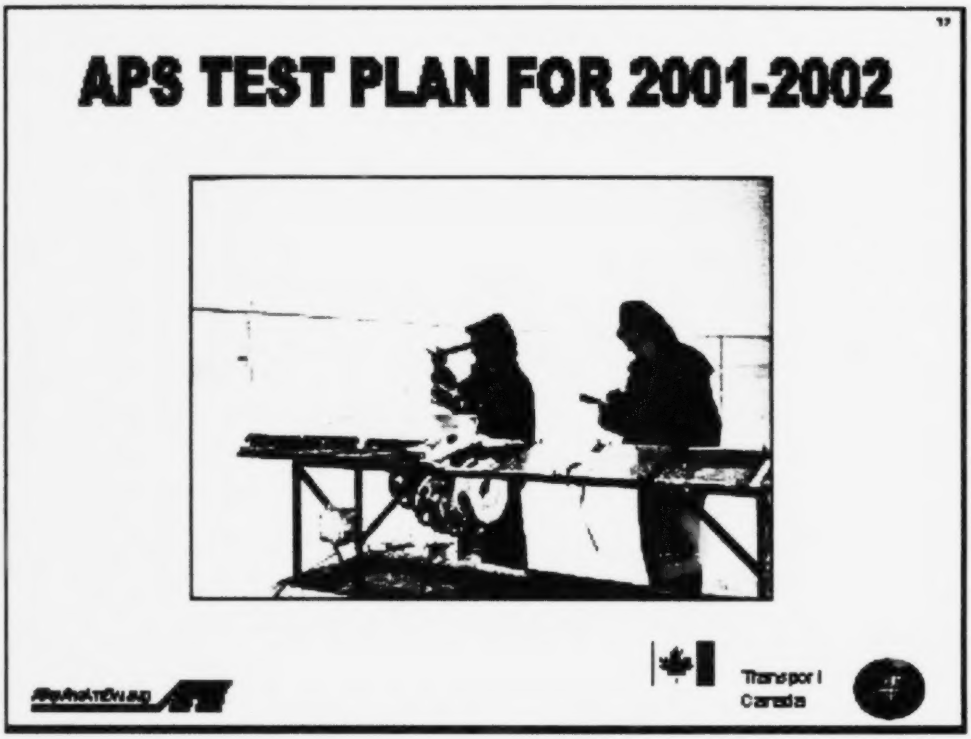
APS TEST PLAN FOR 2001-2002

STAND POSITION	SURFACE TYPE	FLUID		Fluid Conc.	Fluid Type*
		AMOUNT (L)	TEMP (°C)		
1	RATE PAN				
2	Standard plate for ET test	1	20	10° Buffer	E
3	Standard plate for ET test	1	20	10° Buffer	P
4	7.5 cm box (empty)	0.5	60	10° Buffer	E
5	7.5 cm box (empty)	0.5	60	10° Buffer	P

* E – Ethylene (Dow/UCAR EG ADF)

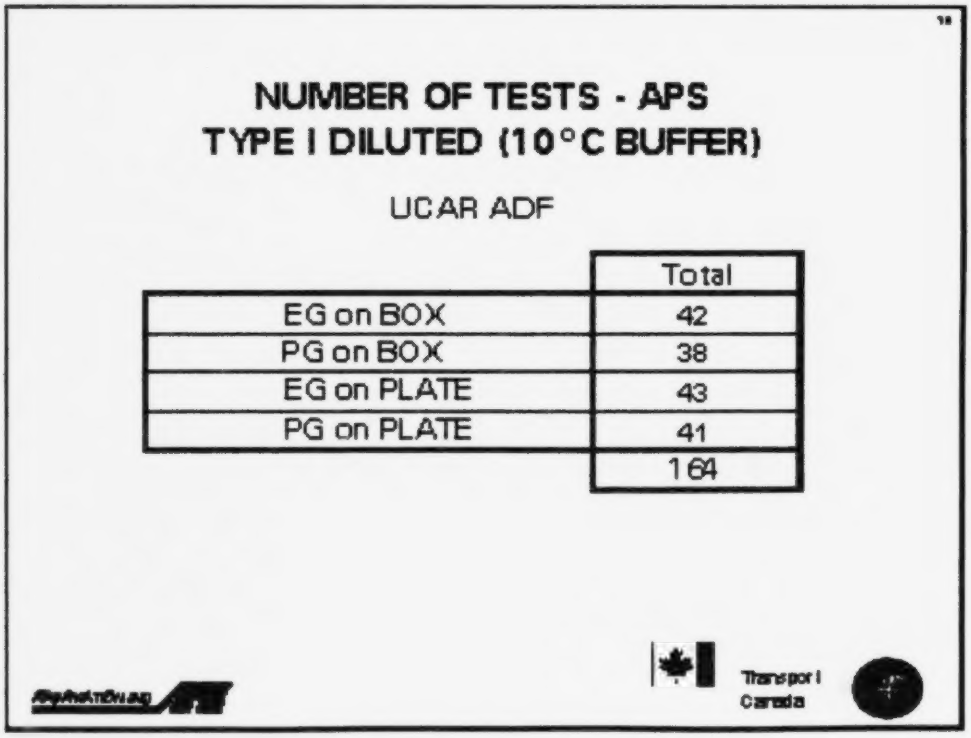
P – Propylene (Dow/UCAR PG ADF)

Transport Canada



APS TEST PLAN FOR 2001-2002

Transport Canada



NUMBER OF TESTS - APS
TYPE I DILUTED (10°C BUFFER)

UCAR ADF

	Total
EG on BOX	42
PG on BOX	38
EG on PLATE	43
PG on PLATE	41
	164

Transport Canada

SUMMARY OF CONDITIONS - APS TESTS

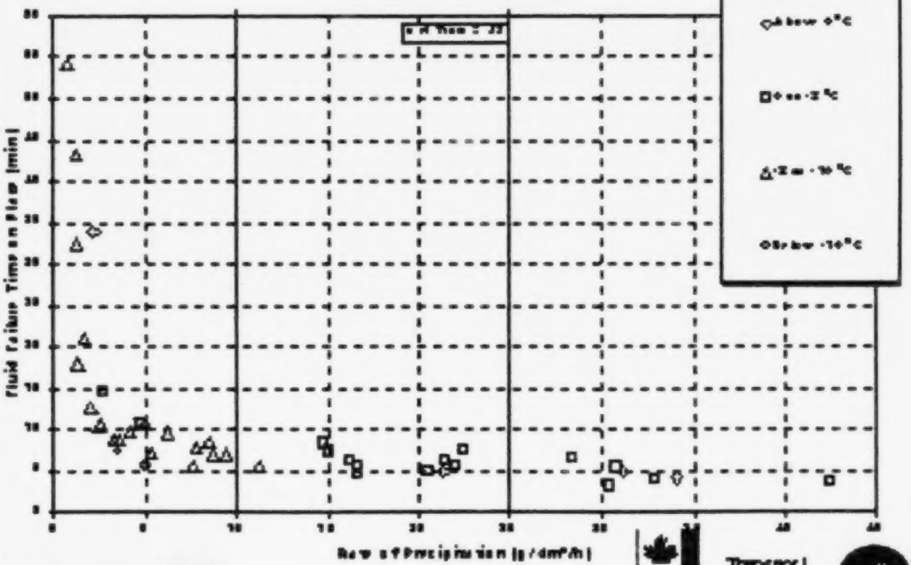
- ☎ 11 Snow Events
- ☎ 164 Fluid Failures
- ☎ Snowfall Rate Between 0.9 and 60.5 g/dm²/h
- ☎ Temperature Between 1.0 and −13.9°C
- ☎ Wind Speed Between 0 and 43 kph

Transport Canada

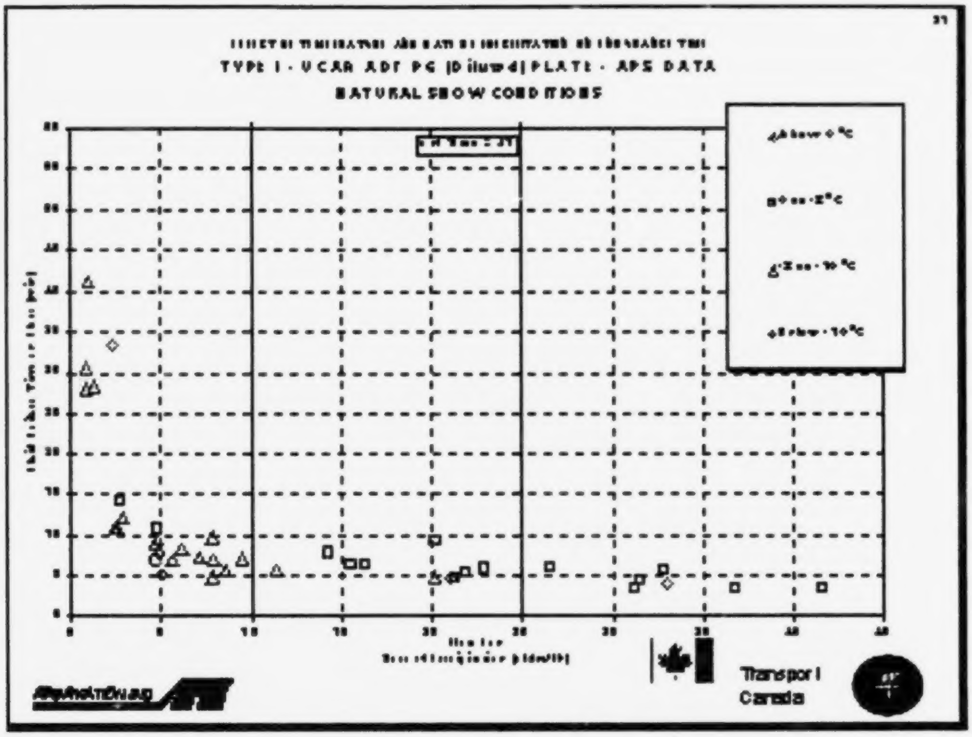
[illegible]

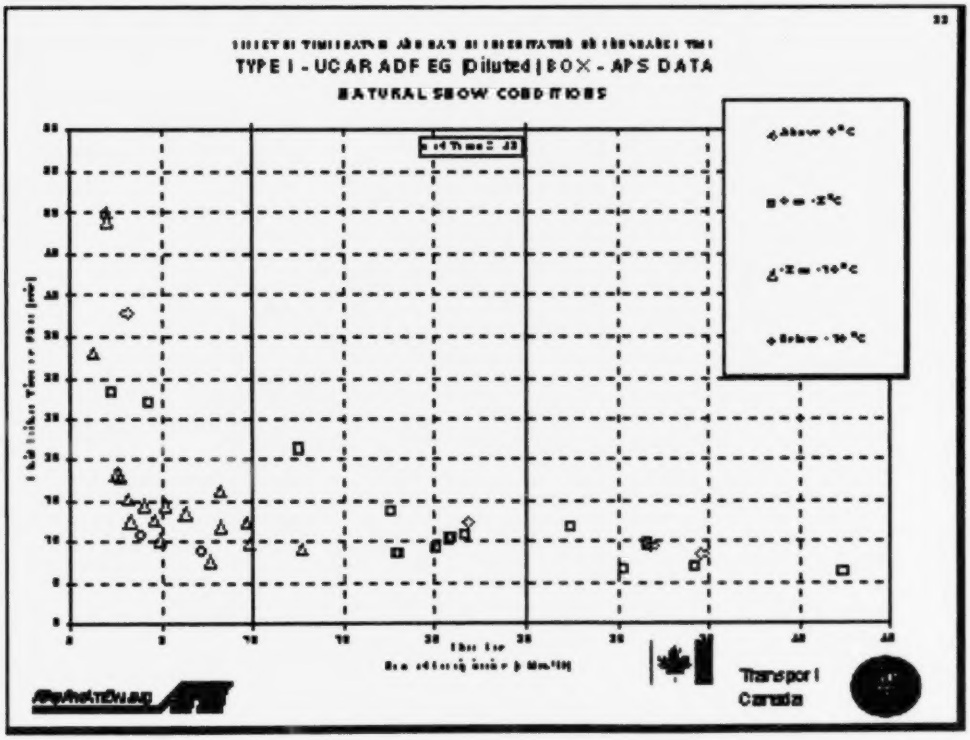
TYPE I - UCAR ADF EG (Diluted) PLATE - APS DATA

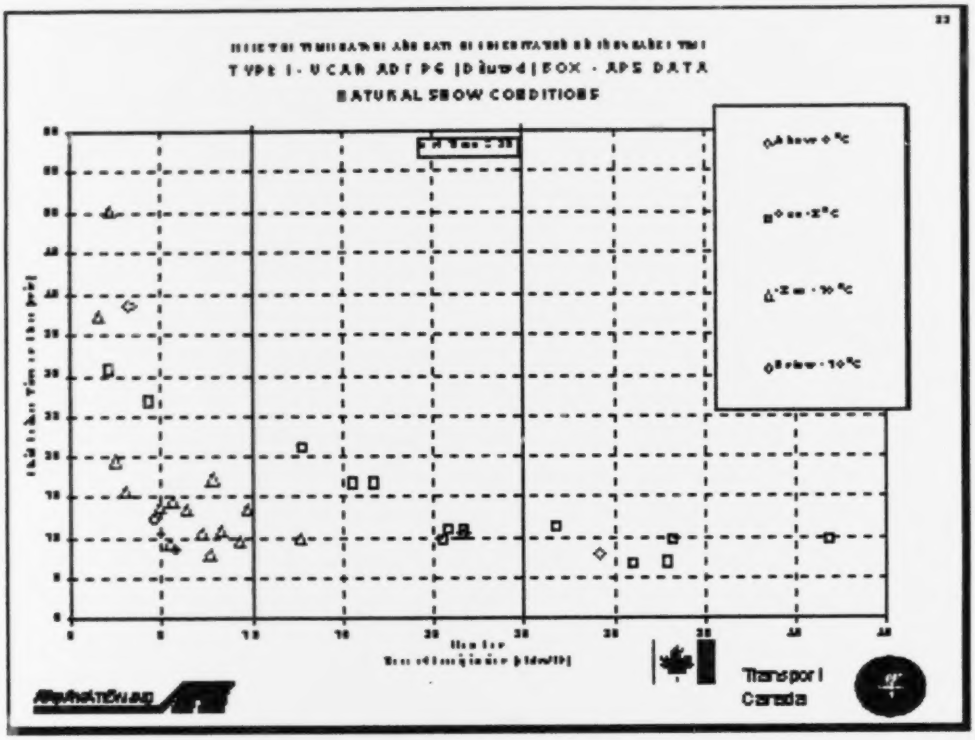
NATURAL SNOW CONDITIONS



Transport Canada

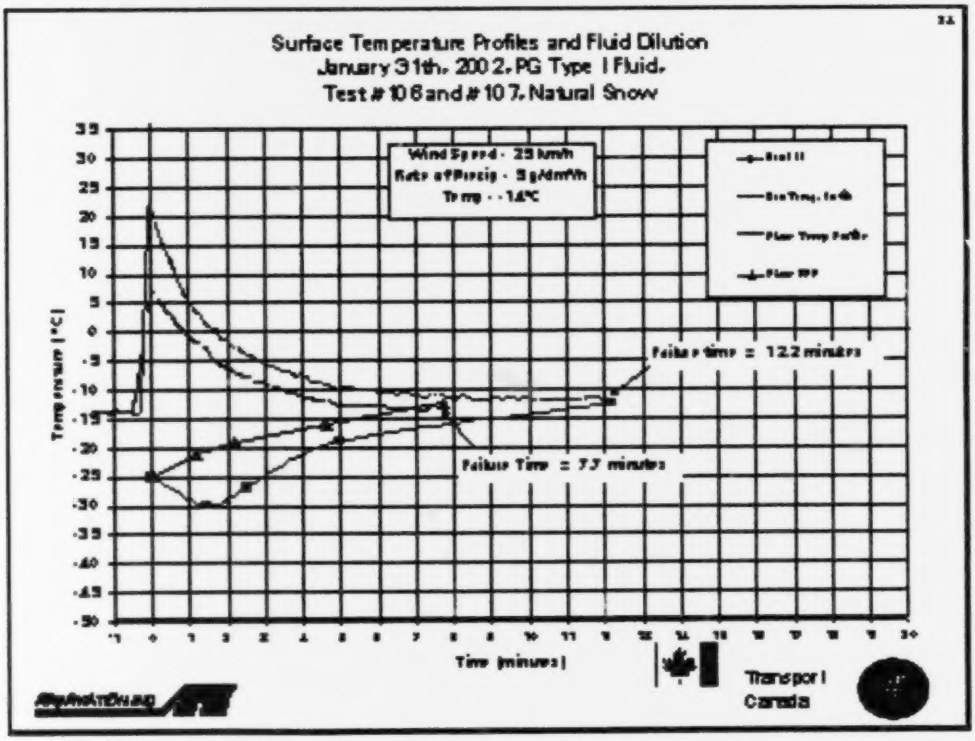

TYPE I - UCAR ADF PG (Diluted) PLATE - APS DATA
NATURAL SNOW CONDITIONS
Above 0°C
0 to -3°C
-3 to -10°C
Below -10°C
Transport Canada
APS


TYPE I - UCAR ADF EG (Diluted) BOX - APS DATA
NATURAL SNOW CONDITIONS
Above 0°C
0 to -3°C
-3 to -10°C
Below -10°C
Transport Canada
APS



TYPE I - UCAR ADF PG (Diluted) BOX - APS DATA

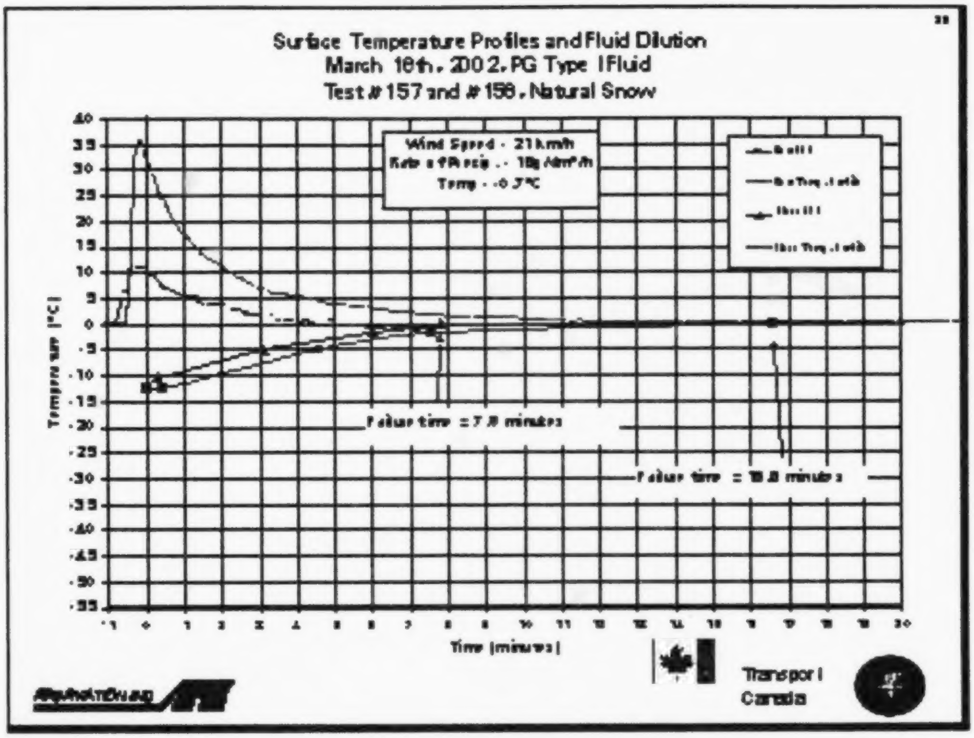
NATURAL SNOW CONDITIONS



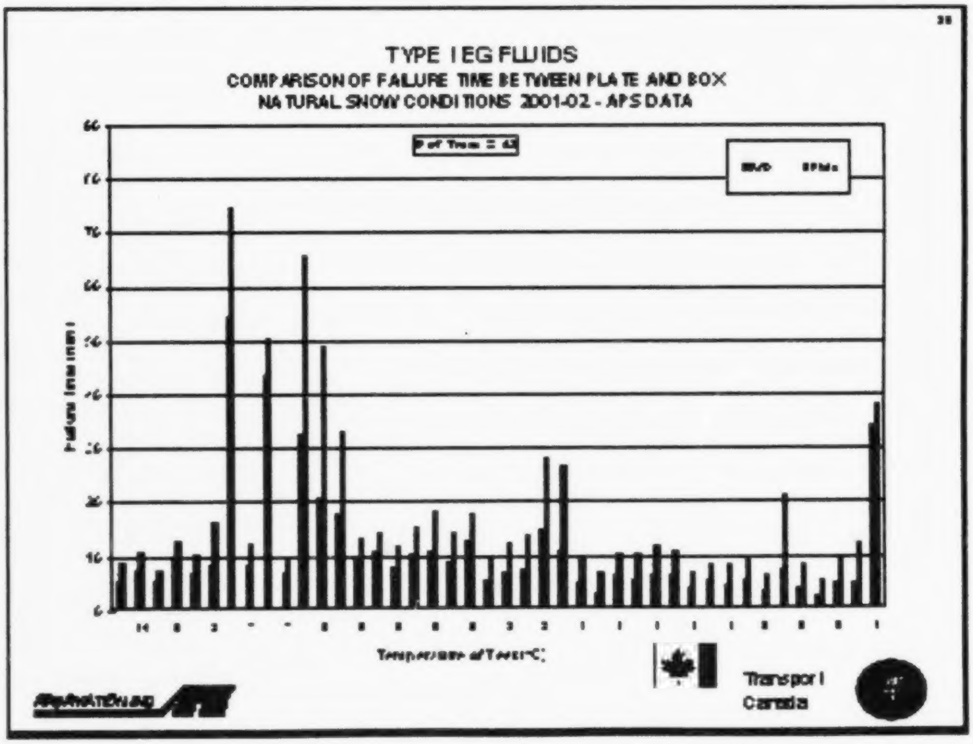
Surface Temperature Profiles and Fluid Dilution

January 31th, 2002, PG Type I Fluid.

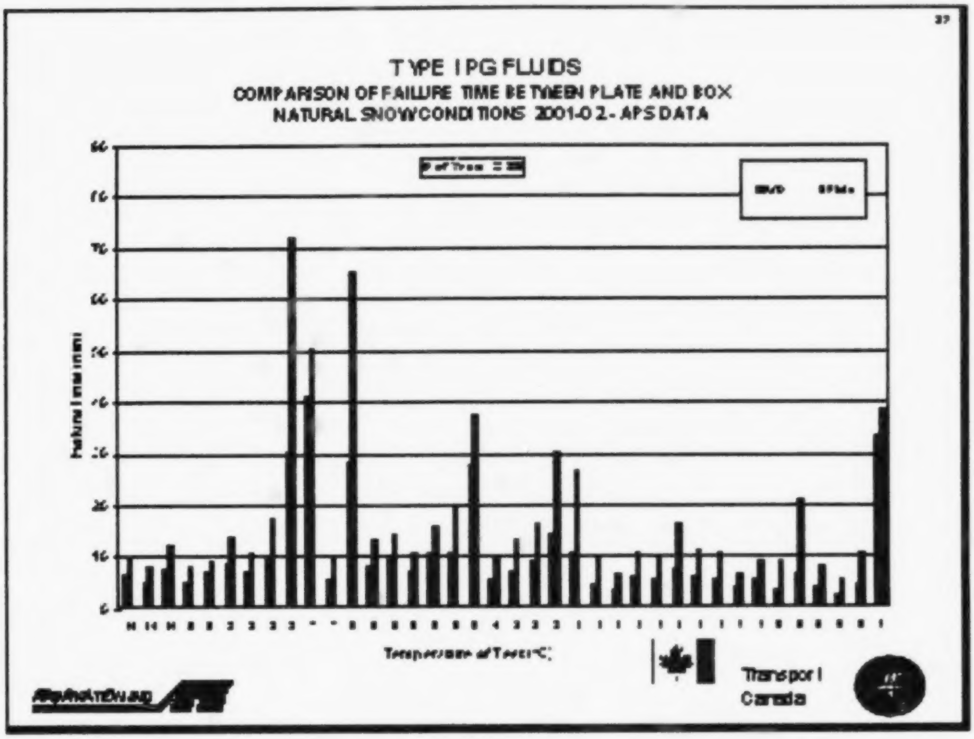
Test # 106 and # 107, Natural Snow



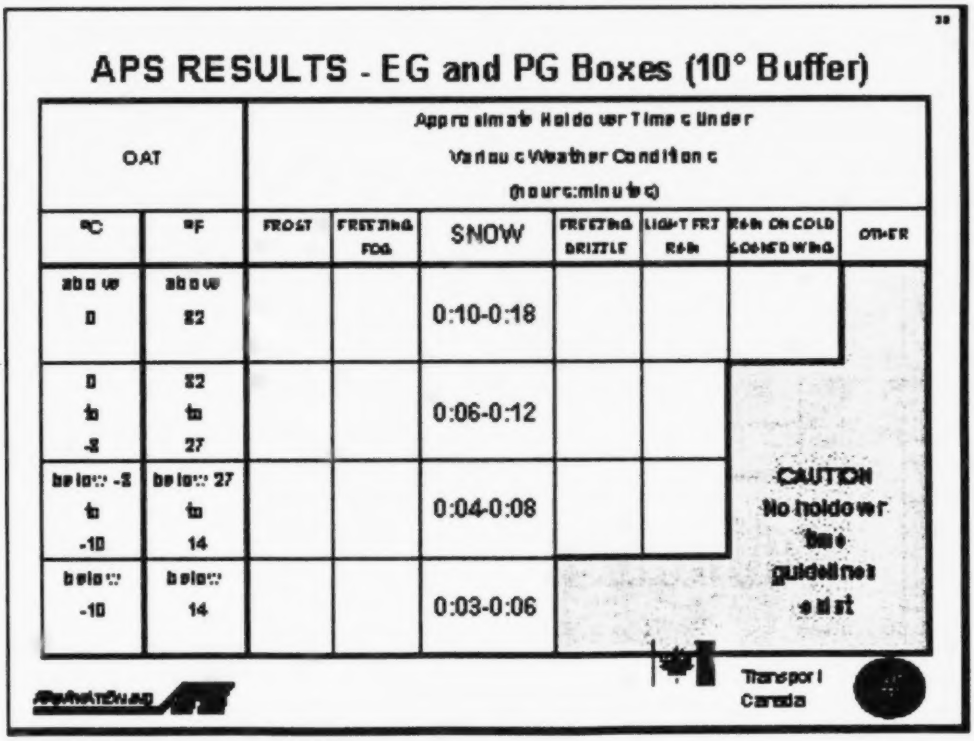
Surface Temperature Profiles and Fluid Dilution
March 18th, 2002, PG Type I Fluid
Test # 157 and # 158, Natural Snow



TYPE I EG FLUIDS
COMPARISON OF FAILURE TIME BETWEEN PLATE AND BOX
NATURAL SNOW CONDITIONS 2001-02 - APS DATA

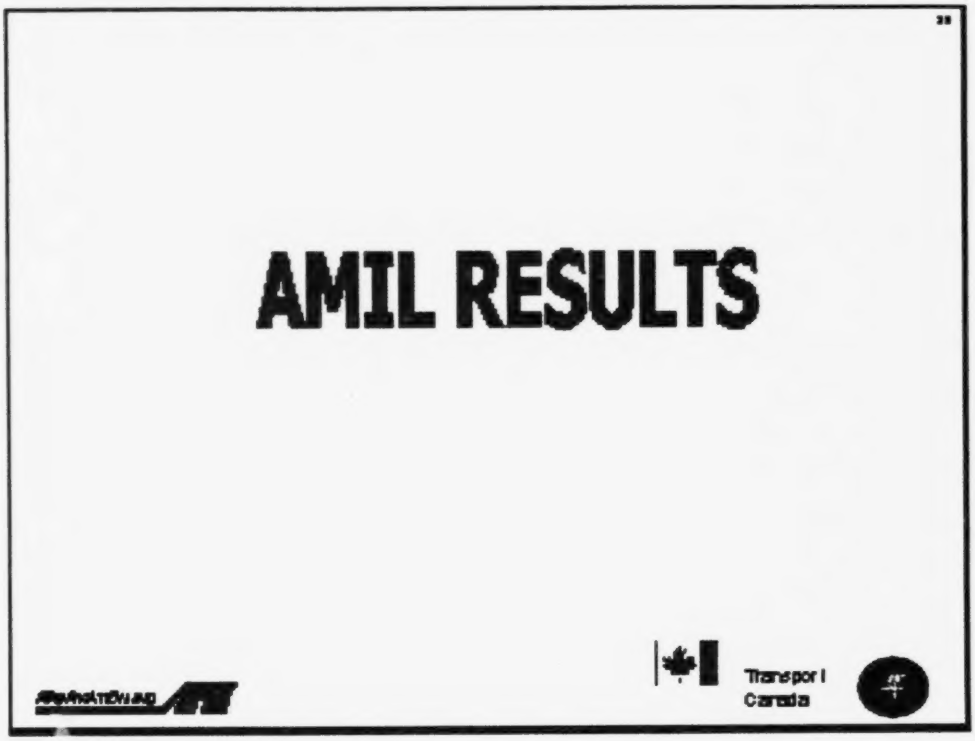


TYPE I PG FLUIDS
COMPARISON OF FAILURE TIME BETWEEN PLATE AND BOX
NATURAL SNOW CONDITIONS 2001-02 - APS DATA


38
Transport Canada

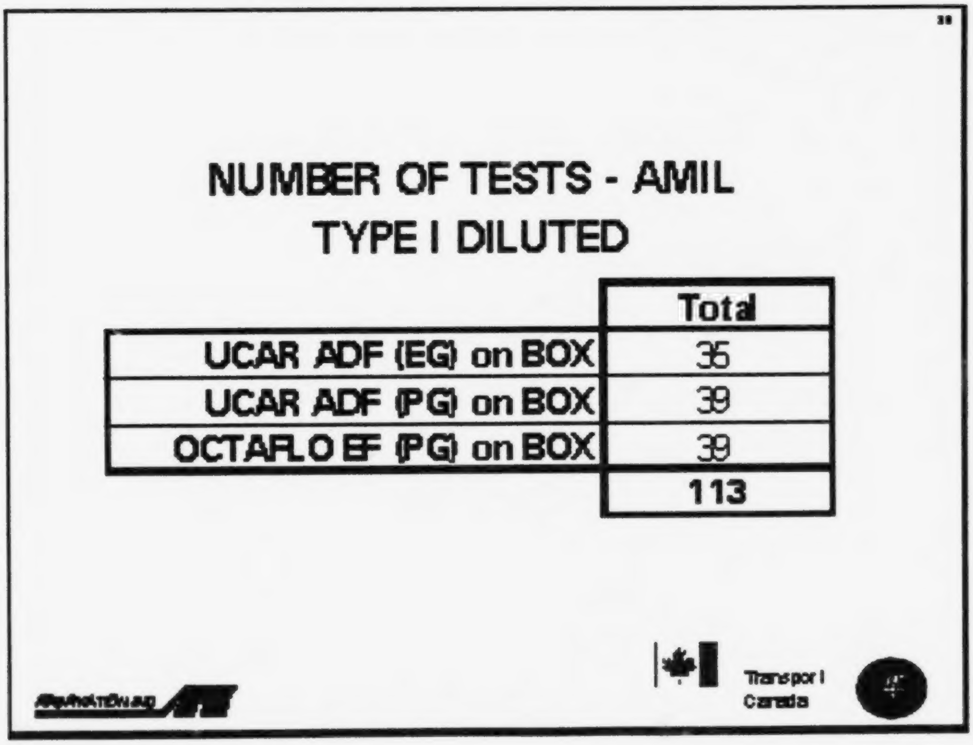
APS RESULTS - EG and PG Boxes (10° Buffer)

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			0:10-0:18				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			0:06-0:12				
below -3 to -10	below 27 to 14			0:04-0:08				
below -10	below 14			0:03-0:06				



AMIL RESULTS

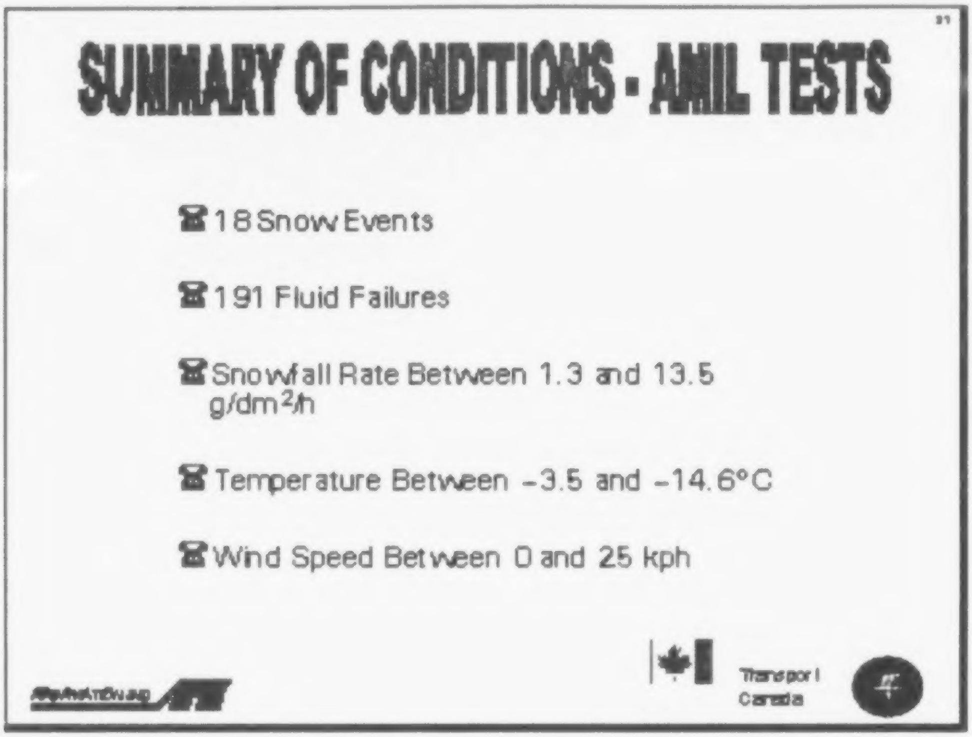
Transport Canada



NUMBER OF TESTS - AMIL
TYPE I DILUTED

	Total
UCAR ADF (EG) on BOX	35
UCAR ADF (PG) on BOX	39
OCTAFLO EF (PG) on BOX	39
	113

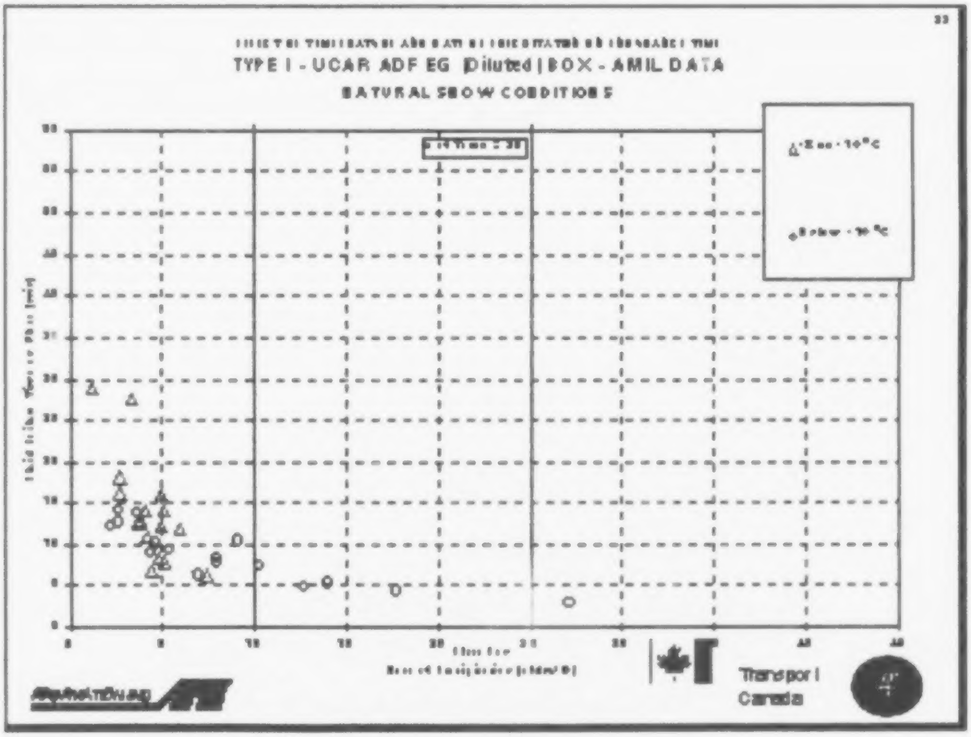
Transport Canada

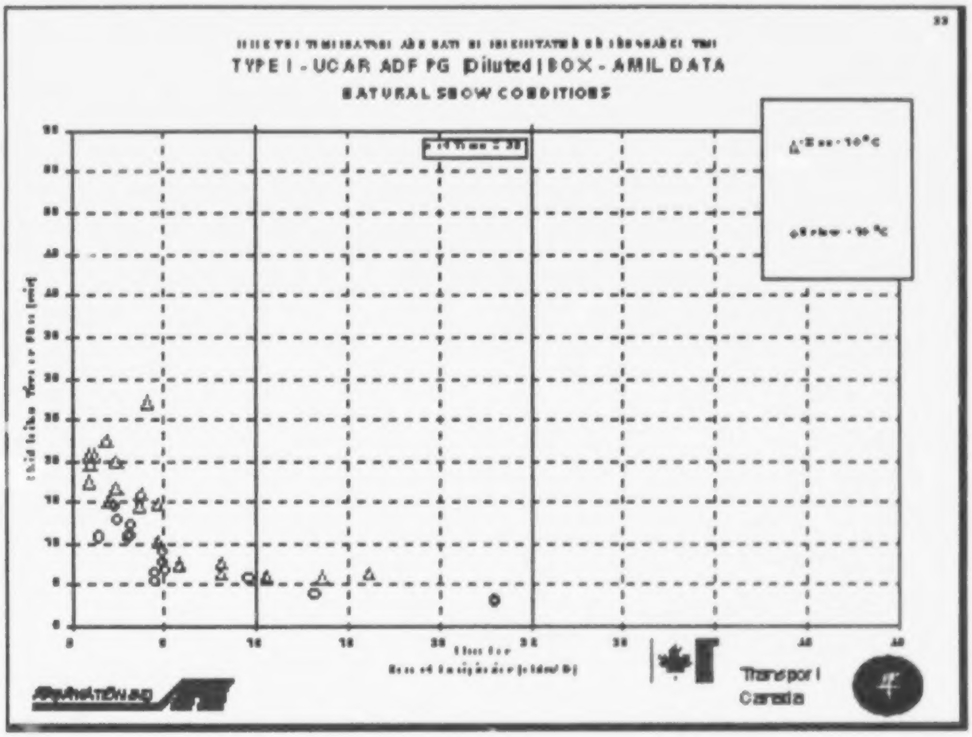


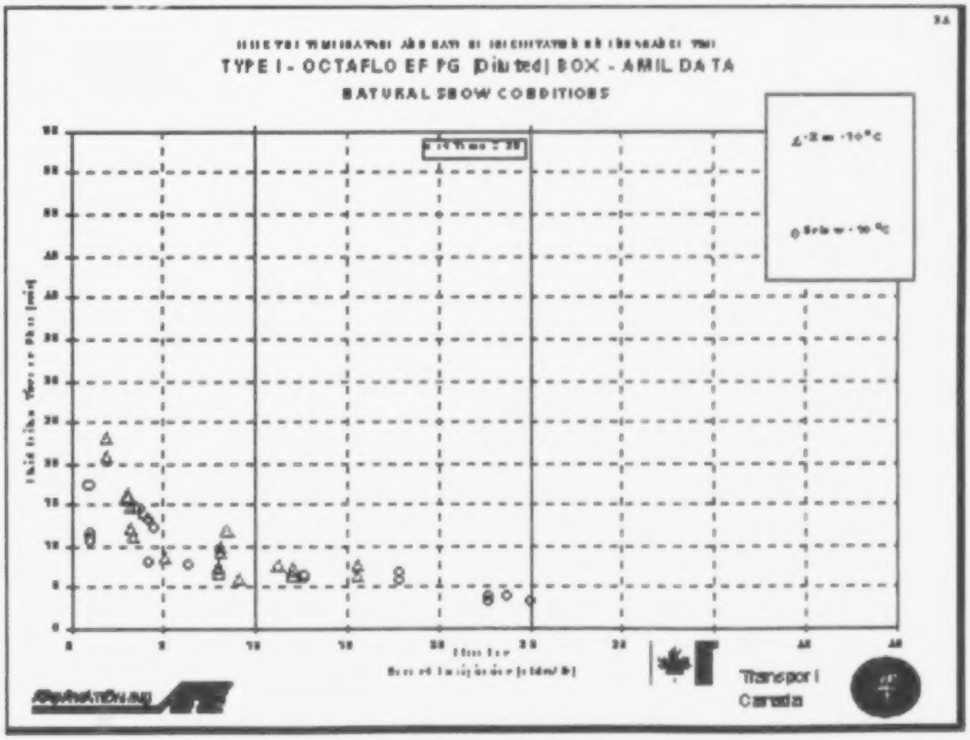
SUMMARY OF CONDITIONS - AMIL TESTS

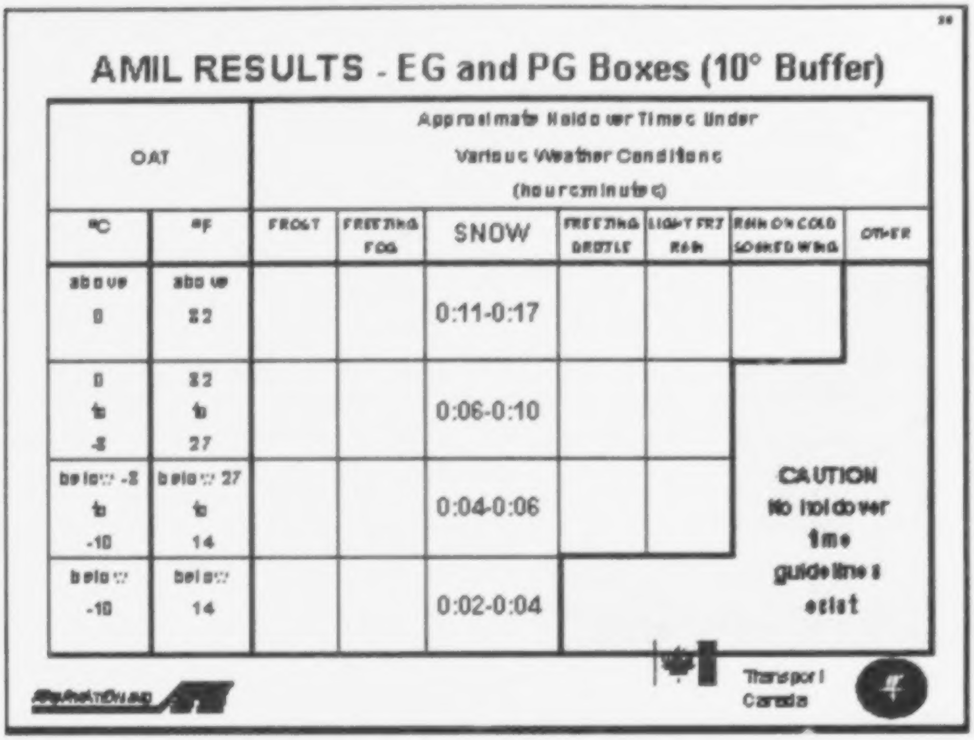
- ☎ 18 Snow Events
- ☎ 191 Fluid Failures
- ☎ Snowfall Rate Between 1.3 and 13.5 g/dm²/h
- ☎ Temperature Between -3.5 and -14.6°C
- ☎ Wind Speed Between 0 and 25 kph

Transport Canada




33
TYPE I - UCAR ADF PG (Diluted) BOX - AMIL DATA
NATURAL SNOW CONDITIONS
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
20
25
30
35
40
45
Transport Canada


34
TYPE I - OCTAFLO EF PG (Diluted) BOX - AMIL DATA
NATURAL SNOW CONDITIONS
0
5
10
15
20
25
30
35
40
45
50
55
60
0
5
10
15
20
25
30
35
40
45
Transport Canada



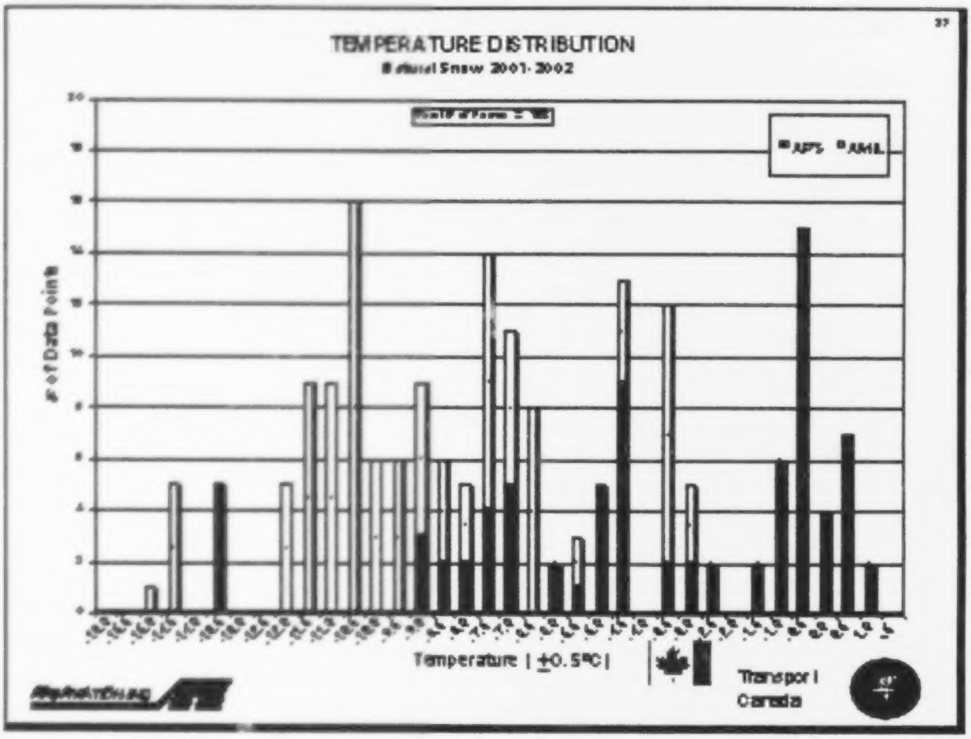
AMIL RESULTS - EG and PG Boxes (10° Buffer)

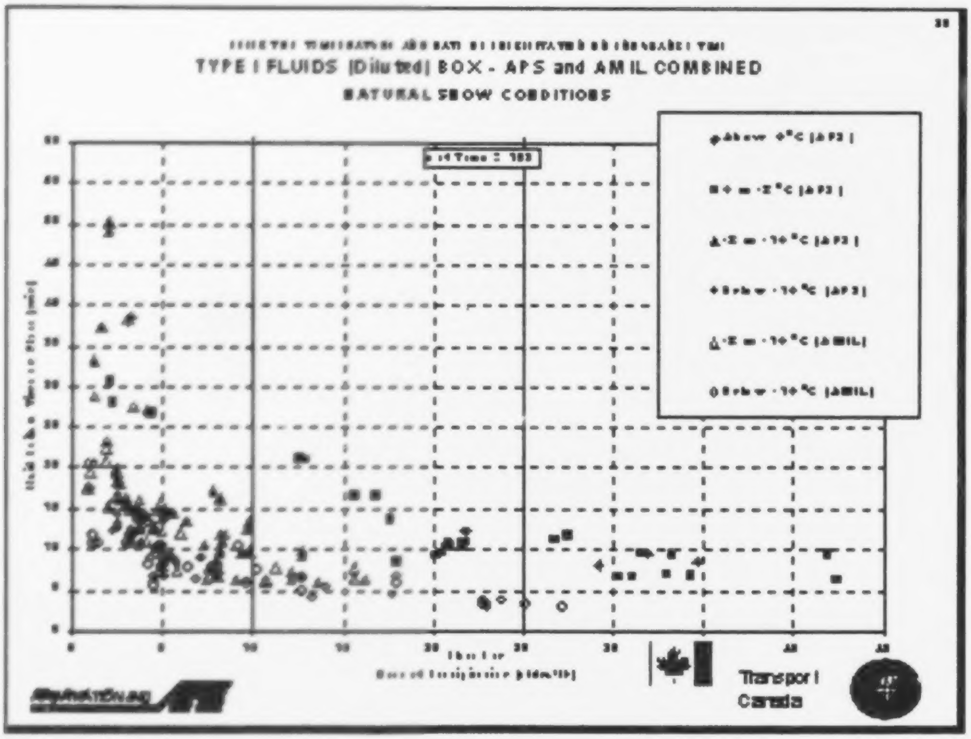
OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			0:11-0:17				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			0:06-0:10				
below -3 to -10	below 27 to 14			0:04-0:06				
below -10	below 14			0:02-0:04				

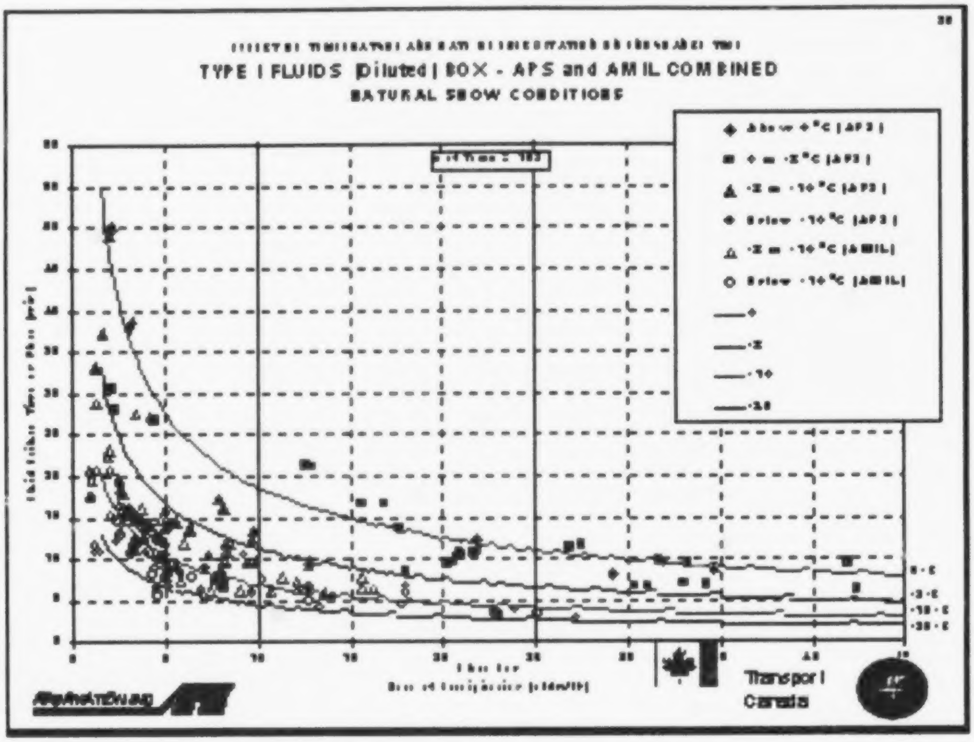
Transport Canada

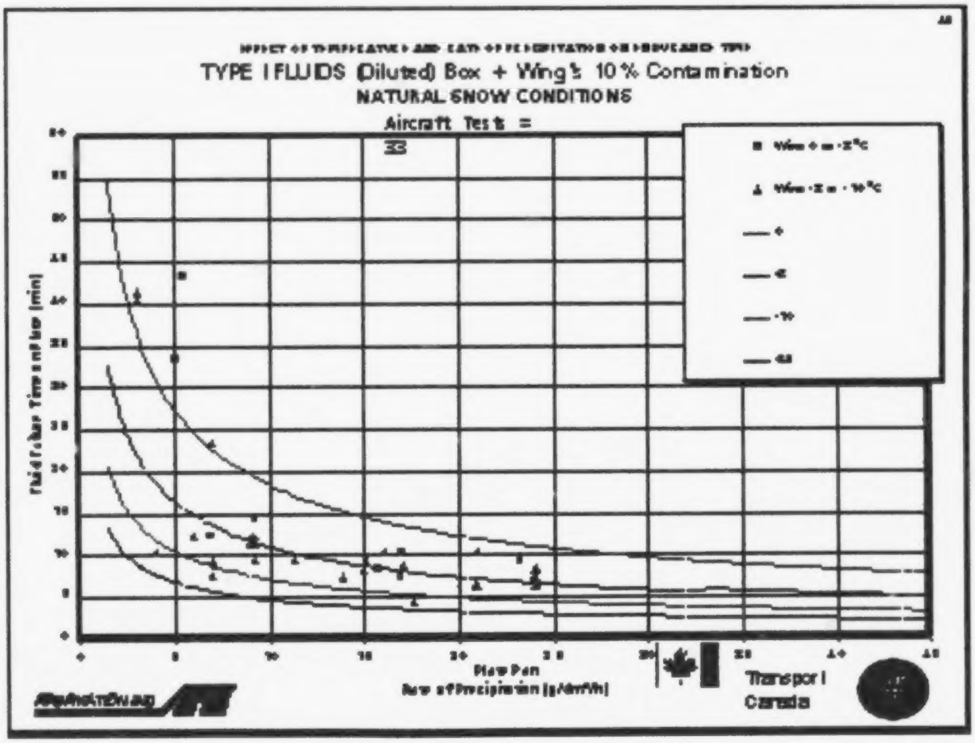
COMBINED RESULTS

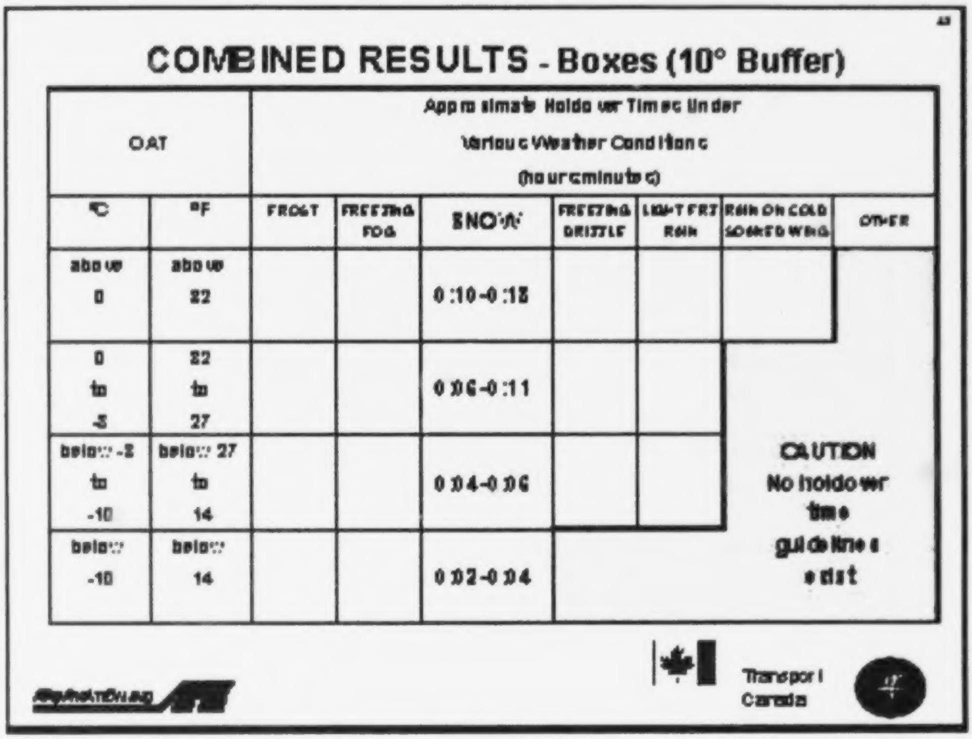
Transport Canada


37
TEMPERATURE DISTRIBUTION
Natural Snow 2001-2002
APS
AMIL
# of Data Points
Temperature (±0.5°C)
APS
Transport Canada


38
TYPE I FLUIDS (Diluted) BOX - APS and AMIL COMBINED
NATURAL SNOW CONDITIONS
APS
Transport Canada


TYPE I FLUIDS (Diluted) BOX - APS and AMIL COMBINED
NATURAL SNOW CONDITIONS
Transport Canada

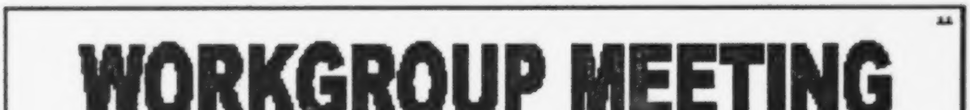

TYPE I FLUIDS (Diluted) Box + Wing's 10% Contamination
NATURAL SNOW CONDITIONS
Aircraft Tests =
33
Fluid Failure Time on Plate (min)
Flow Pan
Rate of Precipitation (g/dm²/h)
Transport Canada



COMBINED RESULTS - Boxes (10° Buffer)

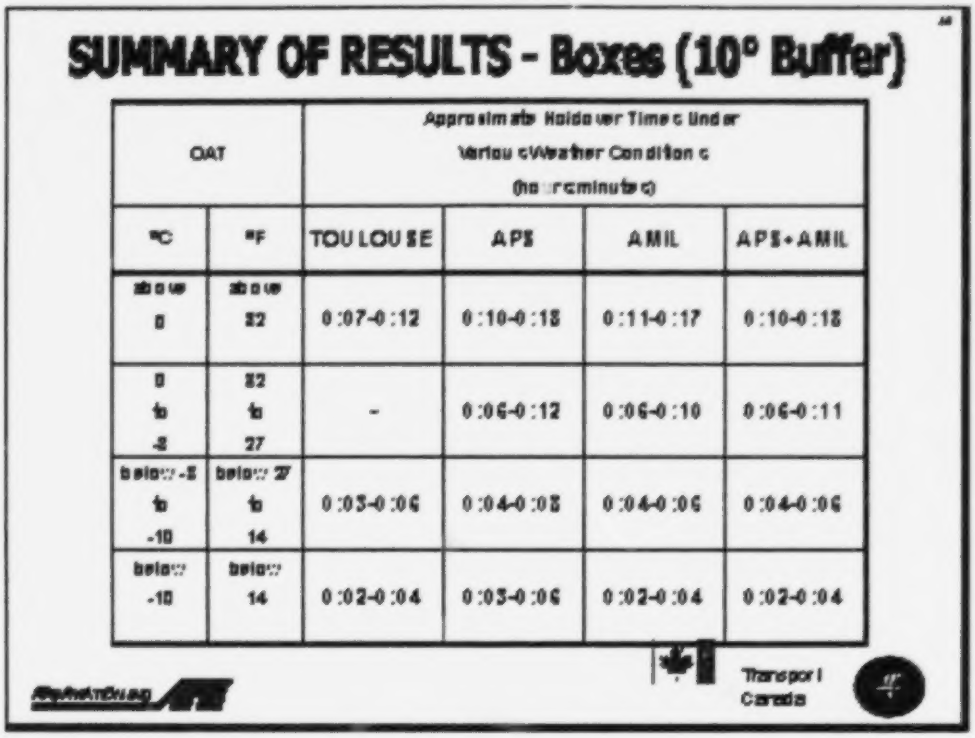
OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32			0:10-0:13				CAUTION No holdover time guidelines exist
0 to -3	32 to 27			0:06-0:11				
below -3 to -10	below 27 to 14			0:04-0:06				
below -10	below 14			0:02-0:04				

Transport Canada



WORKGROUP MEETING

- ☎ A MEETING OF THE HOLDOVER TIME SUBCOMMITTEE WORKGROUP WAS HELD IN MAY 2002 IN MONTREAL
- ☎ THE WORGROUP WAS COMPRISED OF REPRESENTAIVES FROM :
  - ☎ TRANSPORT CANADA
  - ☎ FEDERAL AVIATION ADMINISTRATION
  - ☎ APS AVIATION
  - ☎ AMIL
  - ☎ NCAR
  - ☎ DOW CHEMICAL
- ☎ THE TYPE I TEST RESULTS WERE DISCUSSED AND VALUES FOR EACH CELL OF THE TABLE WERE INITIALLY SELECTED



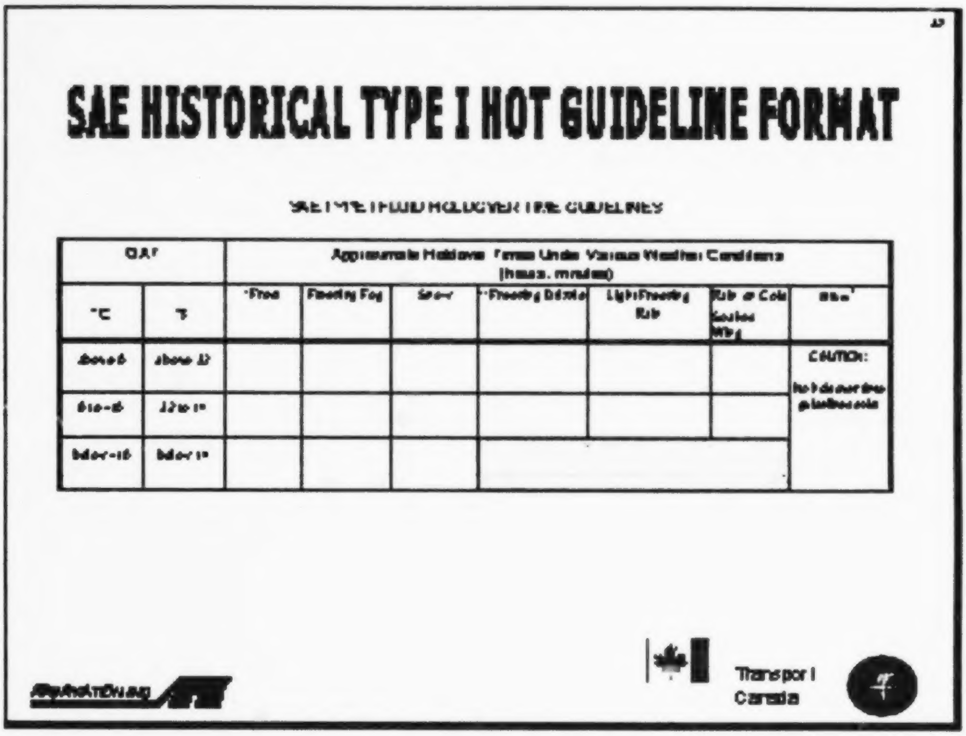
SUMMARY OF RESULTS - Boxes (10° Buffer)

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)			
°C	°F	TOULOUSE	APS	AMIL	APS+AMIL
above 0	above 32	0:07-0:12	0:10-0:18	0:11-0:17	0:10-0:18
0 to -3	32 to 27	-	0:06-0:12	0:06-0:10	0:06-0:11
below -3 to -10	below 27 to 14	0:03-0:06	0:04-0:08	0:04-0:06	0:04-0:06
below -10	below 14	0:02-0:04	0:03-0:06	0:02-0:04	0:02-0:04

Transport Canada

TYPE I HOT GUIDELINE FORMAT

Transport Canada

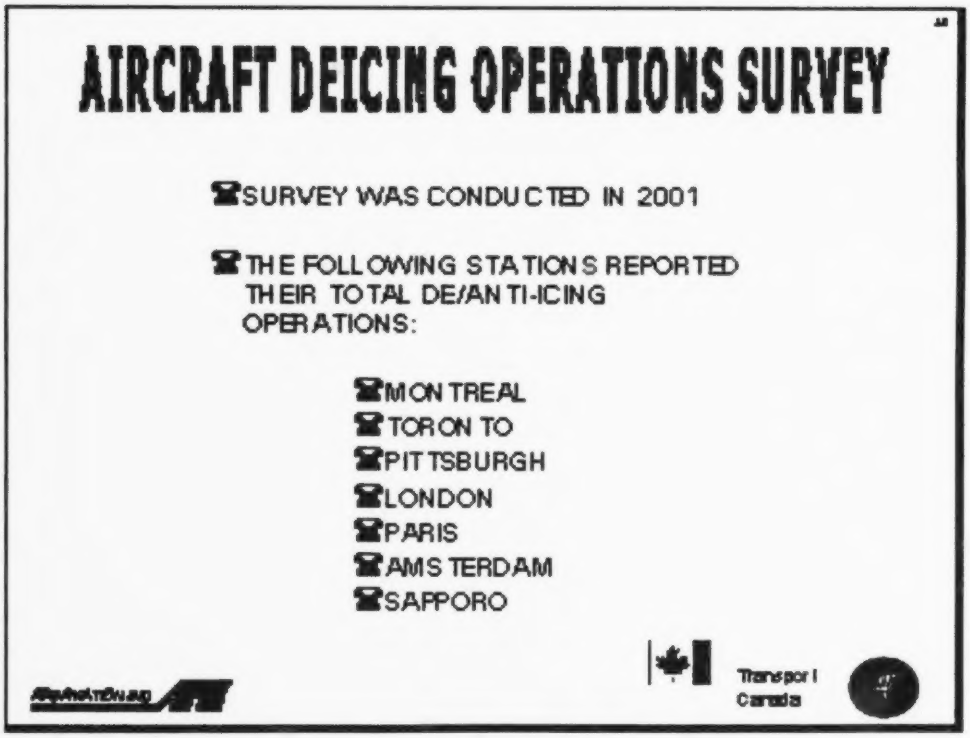


SAE HISTORICAL TYPE I HOT GUIDELINE FORMAT

SAE TYPE I FLUID HOLDOVER TIME GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
°C	°F	*Frost	Freezing Fog	Snow	**Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other†
above 0	above 32							CAUTION: [illegible]
0 to -10	32 to 14							
below -10	below 14							

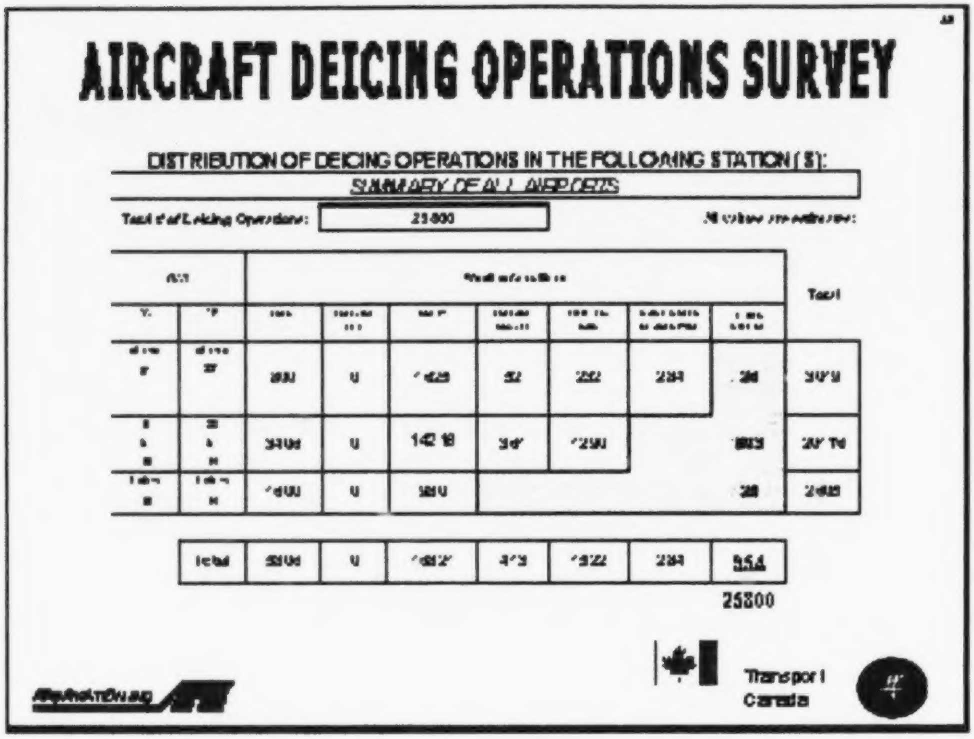
Transport Canada



AIRCRAFT DEICING OPERATIONS SURVEY

- SURVEY WAS CONDUCTED IN 2001
- THE FOLLOWING STATIONS REPORTED THEIR TOTAL DE/ANTI-ICING OPERATIONS:
  - MONTREAL
  - TORONTO
  - PITTSBURGH
  - LONDON
  - PARIS
  - AMSTERDAM
  - SAPPORO

Transport Canada



AIRCRAFT DEICING OPERATIONS SURVEY

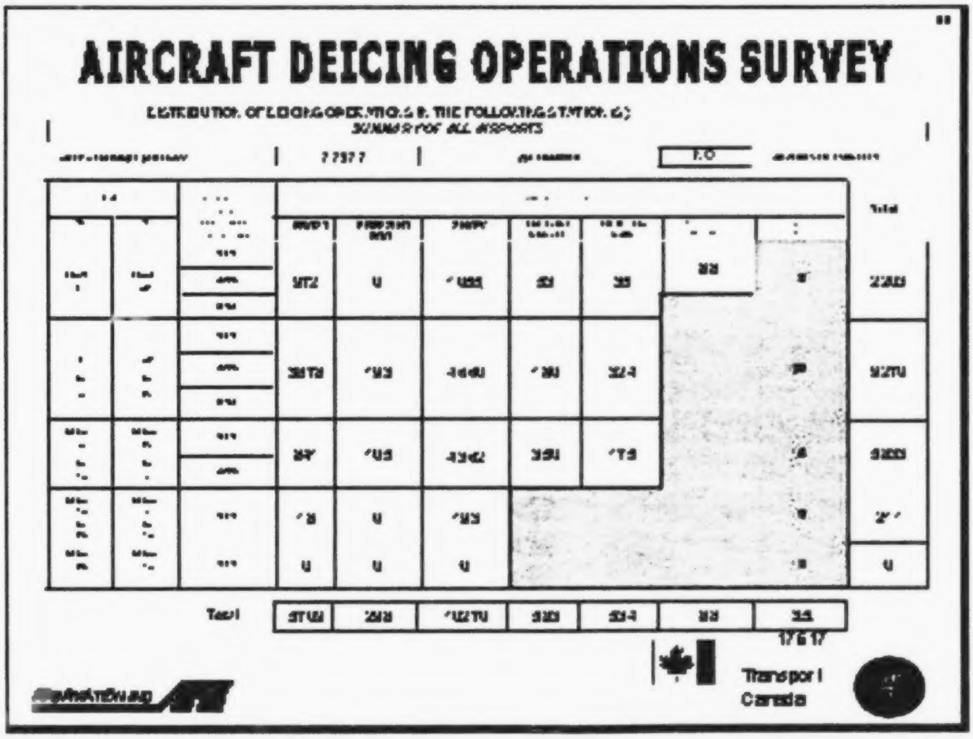
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION(S):

SUMMARY OF ALL AIRPORTS

Total # of Deicing Operations: 25800

25800

Transport Canada



AIRCRAFT DEICING OPERATIONS SURVEY

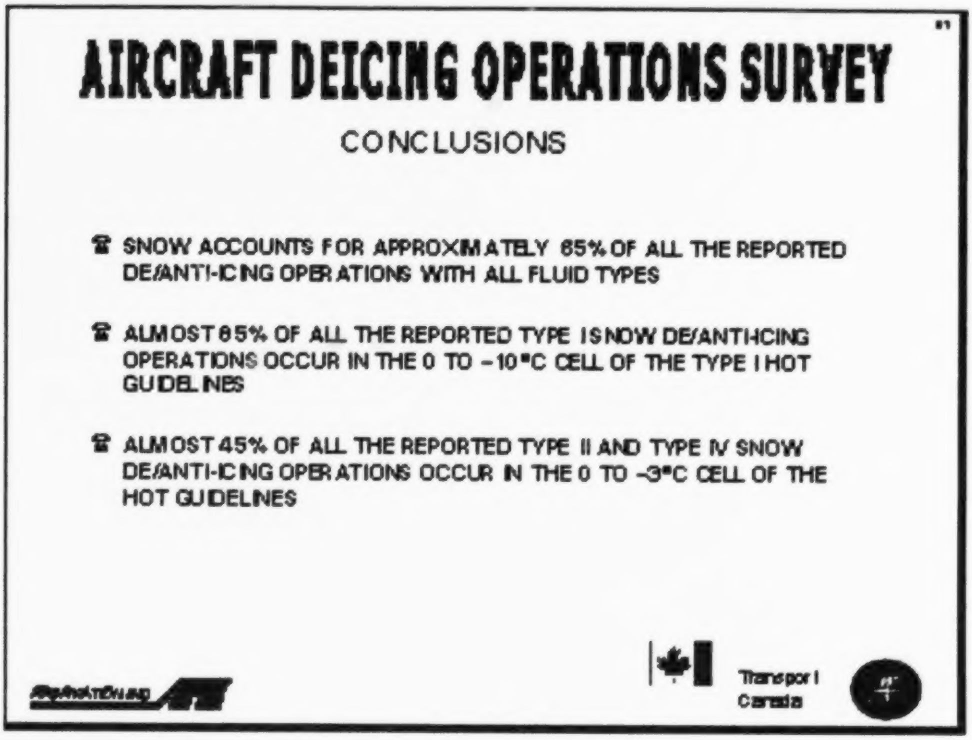
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION(S):

SUMMARY OF ALL AIRPORTS

Total

17617

Transport Canada

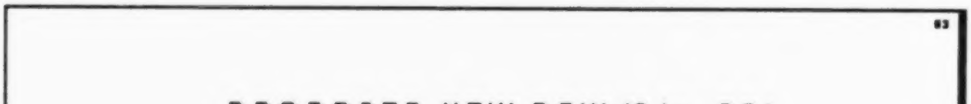


AIRCRAFT DEICING OPERATIONS SURVEY

CONCLUSIONS

- ☎ SNOW ACCOUNTS FOR APPROXIMATELY 65% OF ALL THE REPORTED DE/ANTI-ICING OPERATIONS WITH ALL FLUID TYPES
- ☎ ALMOST 65% OF ALL THE REPORTED TYPE I SNOW DE/ANTI-ICING OPERATIONS OCCUR IN THE 0 TO −10°C CELL OF THE TYPE I HOT GUIDELINES
- ☎ ALMOST 45% OF ALL THE REPORTED TYPE II AND TYPE IV SNOW DE/ANTI-ICING OPERATIONS OCCUR IN THE 0 TO −3°C CELL OF THE HOT GUIDELINES

Transport Canada

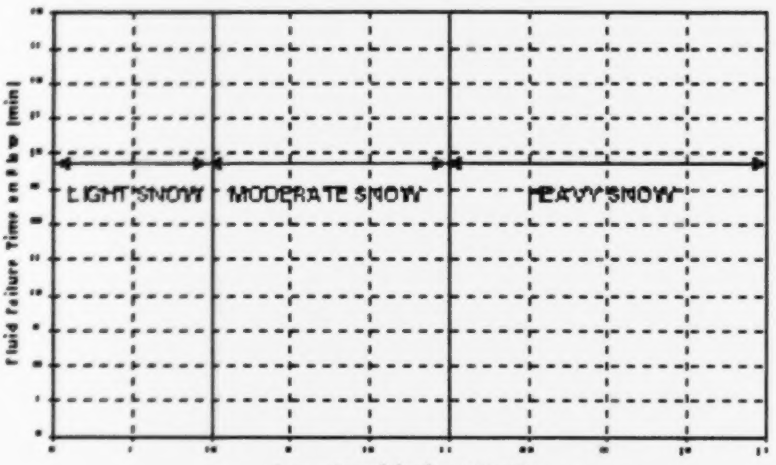


PROPOSED NEW ROW (0 to -3C)

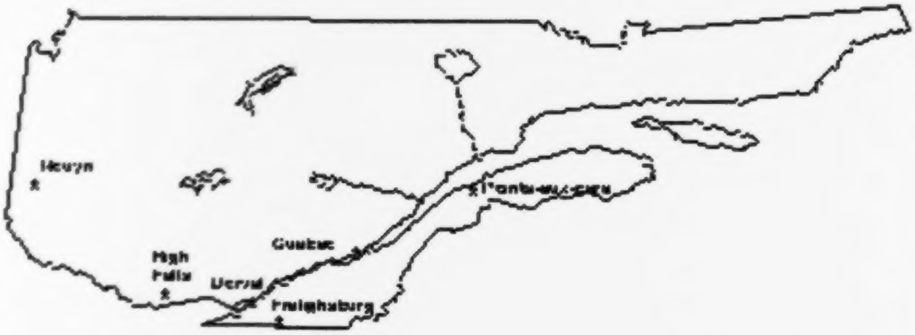
OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER
above 0	above 32							
0 to -3	32 to 27							
-3 to -10	27 to 14							CAUTION No holdover time guidelines exist
below -10	below 14							

Transport Canada

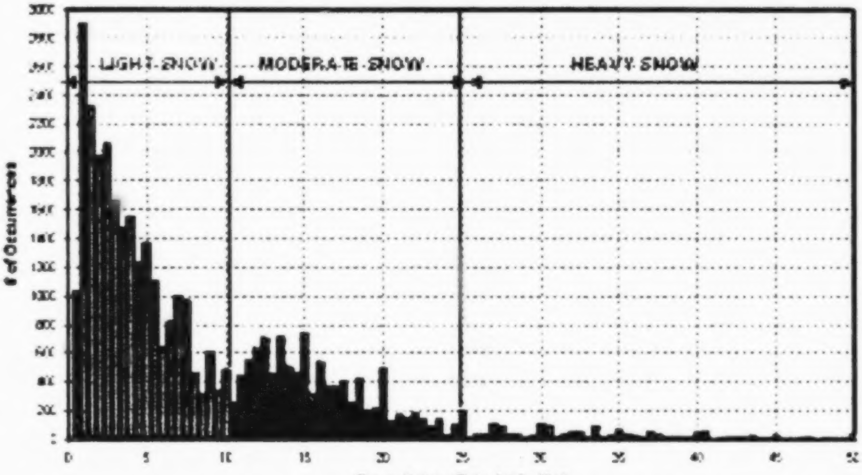
SAE HOT SUBCOMMITTEE SNOW RATE DEFINITIONS



EVALUATION OF WINTER WEATHER DATA (1995-2001)

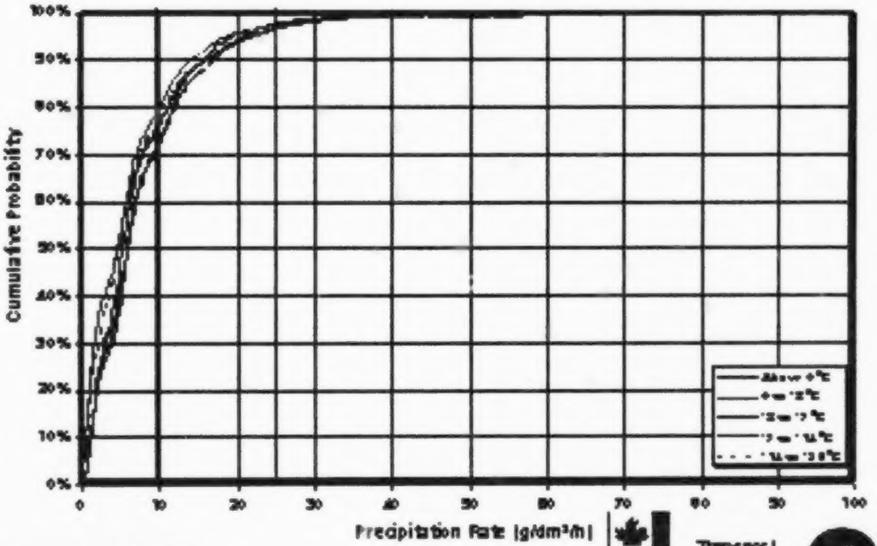

Rouyn
High Falls
Dorval
Quebec
Frelighsburg

Precipitation Rate Distribution between -3 and -7°C

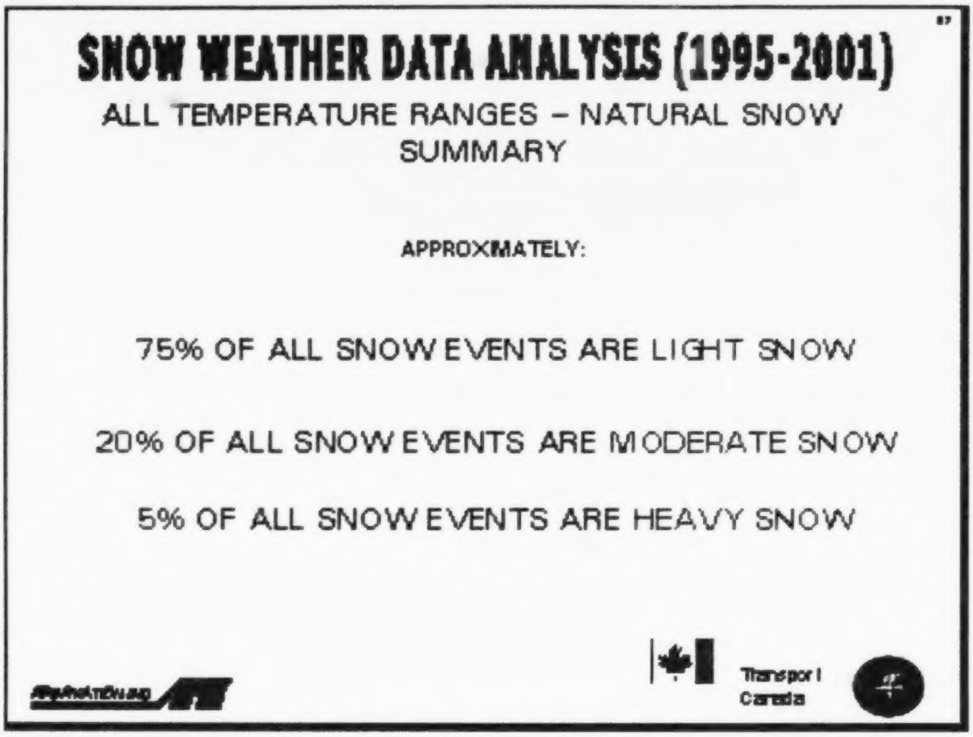


Transport Canada

SNOW WEATHER DATA ANALYSIS (1995-2001)
ALL TEMPERATURE RANGES - NATURAL SNOW



Transport Canada



SNOW WEATHER DATA ANALYSIS (1995-2001)

ALL TEMPERATURE RANGES – NATURAL SNOW SUMMARY

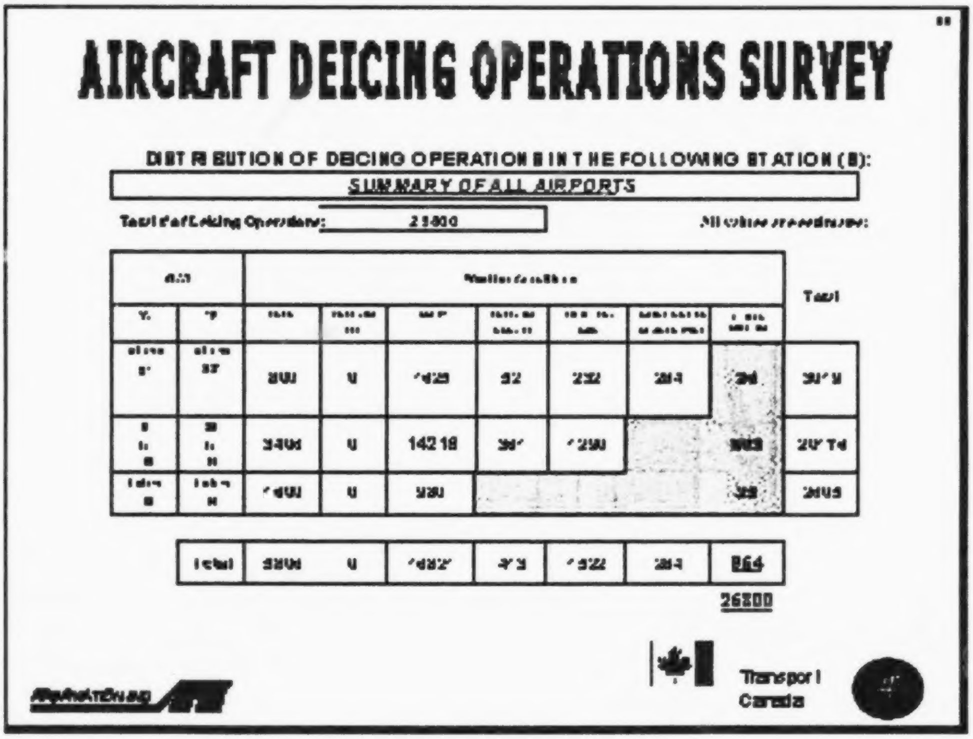
APPROXIMATELY:

75% OF ALL SNOW EVENTS ARE LIGHT SNOW

20% OF ALL SNOW EVENTS ARE MODERATE SNOW

5% OF ALL SNOW EVENTS ARE HEAVY SNOW

Transport Canada



AIRCRAFT DEICING OPERATIONS SURVEY

DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

SUMMARY OF ALL AIRPORTS

Total # of Deicing Operations: 26800

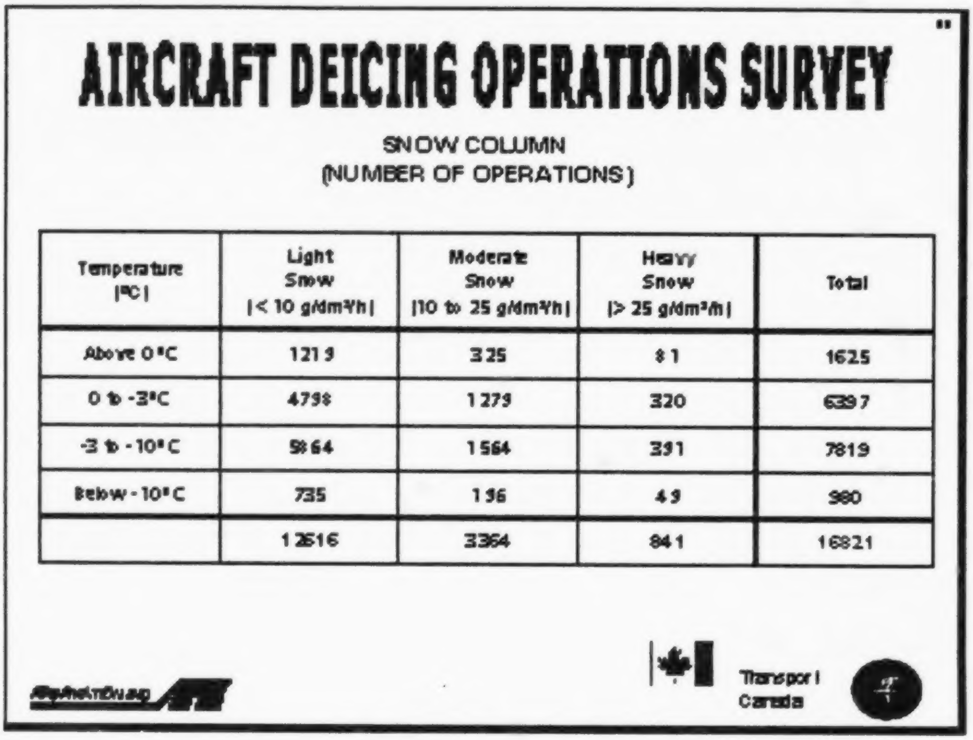
[illegible]

[illegible]		[illegible]							Total
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	0	[illegible]	52	232	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0	142 18	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0	[illegible]				[illegible]	[illegible]

Total	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	864

26800

Transport Canada

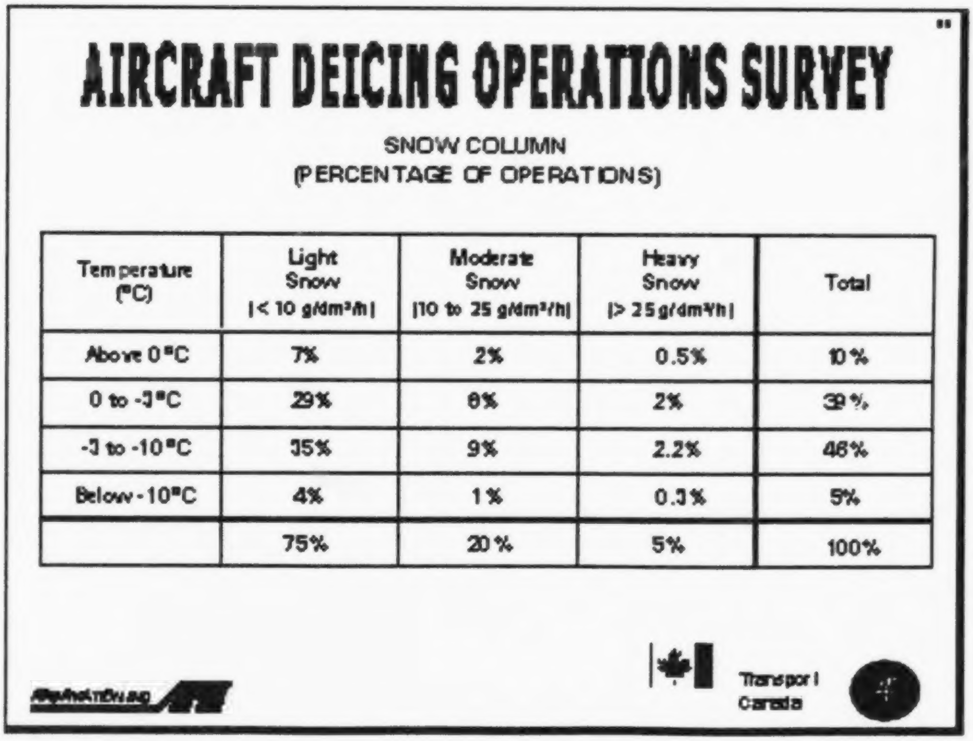


AIRCRAFT DEICING OPERATIONS SURVEY

SNOW COLUMN
(NUMBER OF OPERATIONS)

Temperature (°C)	Light Snow (< 10 g/dm^2/h)	Moderate Snow (10 to 25 g/dm^2/h)	Heavy Snow (> 25 g/dm^2/h)	Total
Above 0°C	1219	325	81	1625
0 to -3°C	4798	1279	320	6397
-3 to -10°C	5864	1564	391	7819
Below -10°C	735	196	49	980
	12616	3364	841	16821

Transport Canada

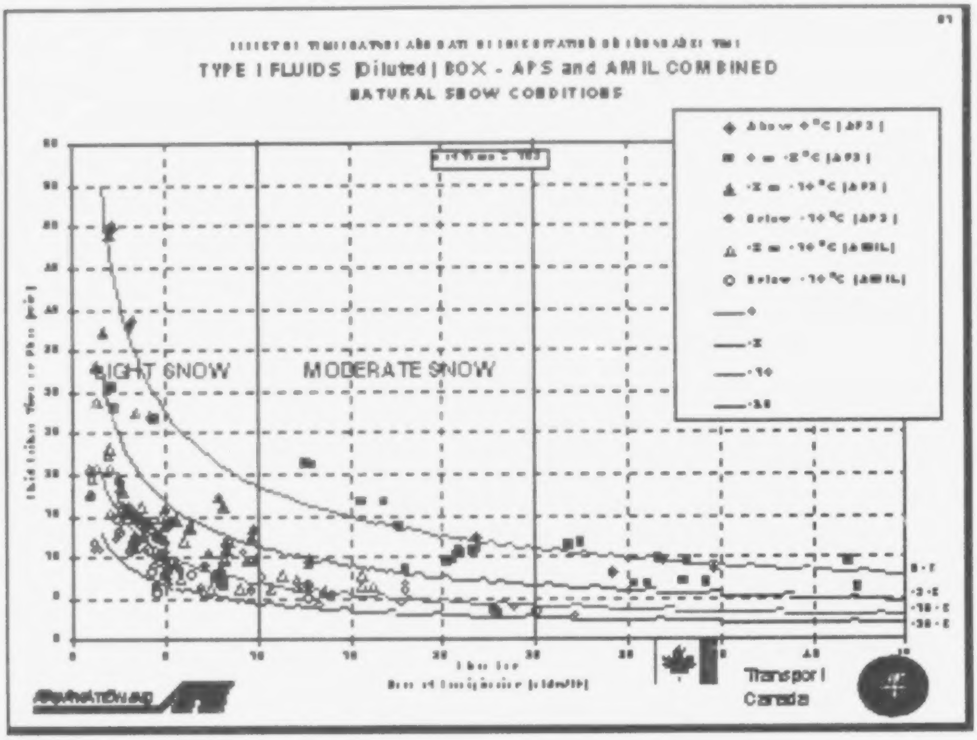


AIRCRAFT DEICING OPERATIONS SURVEY

SNOW COLUMN
(PERCENTAGE OF OPERATIONS)

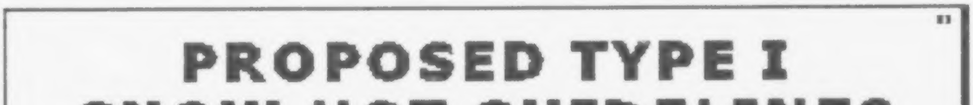
Temperature (°C)	Light Snow (< 10 g/dm^2/h)	Moderate Snow (10 to 25 g/dm^2/h)	Heavy Snow (> 25 g/dm^2/h)	Total
Above 0°C	7%	2%	0.5%	10%
0 to -3°C	29%	8%	2%	39%
-3 to -10°C	35%	9%	2.2%	46%
Below -10°C	4%	1%	0.3%	5%
	75%	20%	5%	100%

Transport Canada



TYPE I FLUIDS (Diluted) BOX - APS and AMIL COMBINED

NATURAL SNOW CONDITIONS

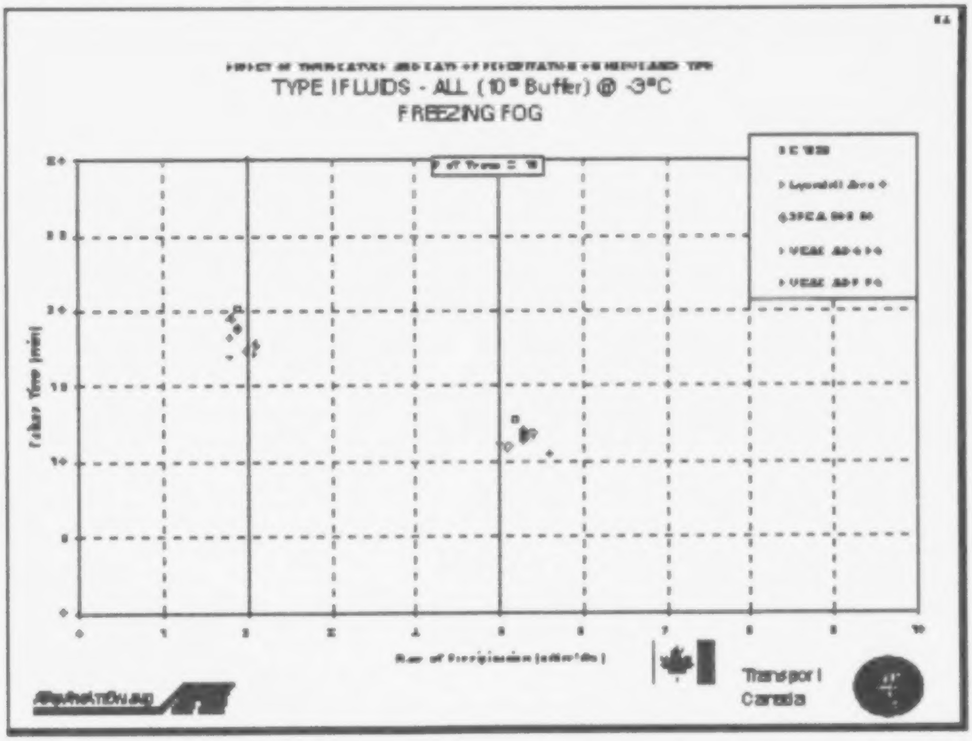


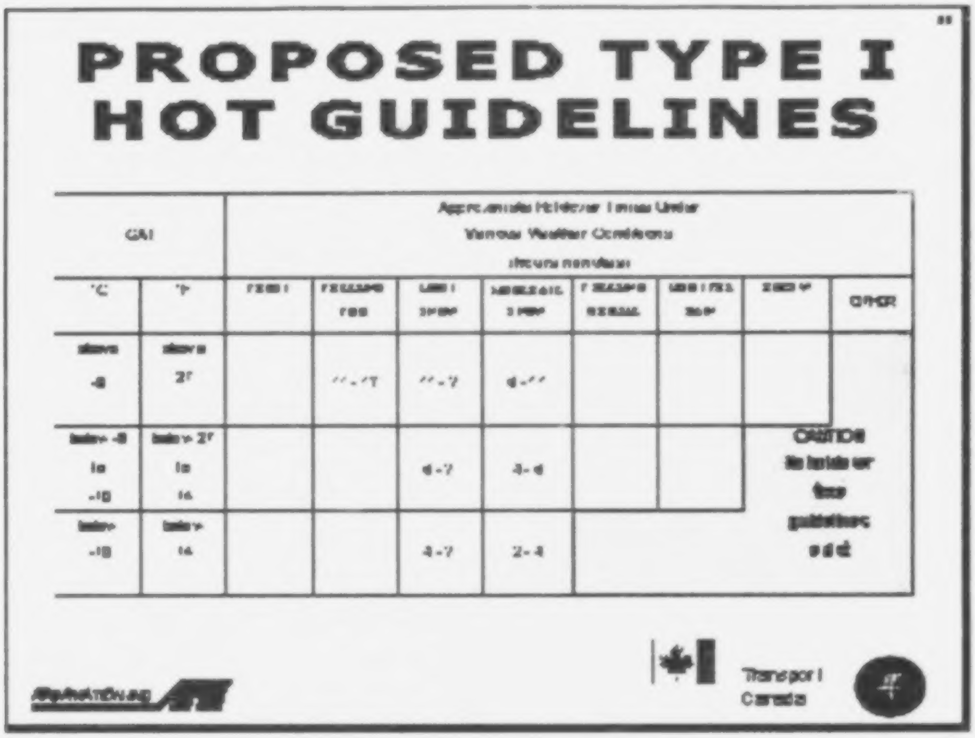
PROPOSED TYPE I SNOW HOT GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F	FROST	FREEZING FOG	LIGHT SNOW	MODERATE SNOW	FREEZING DRIZZLE	[illegible]	[illegible]	OTHER
above -3	above 27			[illegible] - 7	6 - [illegible]				
below -3 to -10	below 27 to 14			6 - 7	4 - 6			CAUTION No holdover time guidelines exist	
below -10	below 14			4 - 7	2 - 3				

Transport
Canada

FLUID ENDURANCE TIME TESTS AT -3C


TYPE I FLUIDS - ALL (10° Buffer) @ -3°C
FREEZING FOG



PROPOSED TYPE I HOT GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	OTHER
above -3	above 27		11-17	[illegible]	6-11				
below -3 to -10	below 27 to 14			6-7	3-6			CAUTION No holdover time guidelines exist	
below -10	below 14			4-7	2-4				

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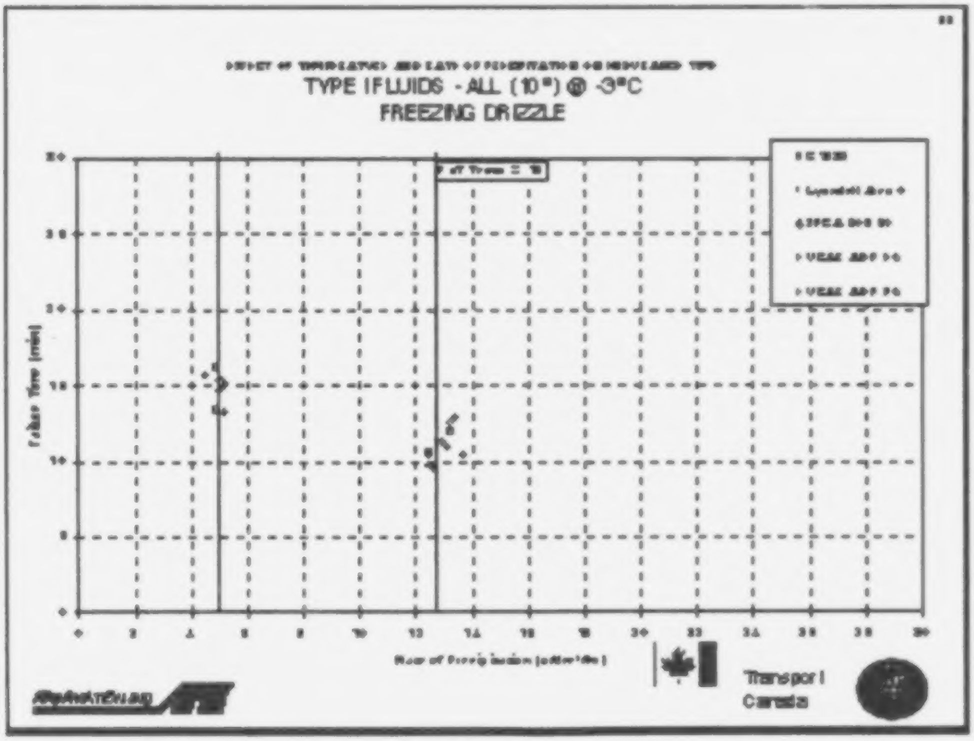

[illegible]

TYPE I FLUIDS - ALL (10°) @ -3°C

FREEZING DRIZZLE

Transport Canada

PROPOSED TYPE I HOT GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F	FROST	FREEZING FOG	LIGHT SNOW	MODERATE SNOW	FREEZING DRIZZLE	[illegible]	[illegible]	OTHER
above -3	above 27		[illegible]	[illegible]	6-[illegible]	9-13			
below -3 to -10	below 27 to 14			6-7	4-6			CAUTION No holdover time guidelines exist	
below -10	below 14			4-7	2-4				

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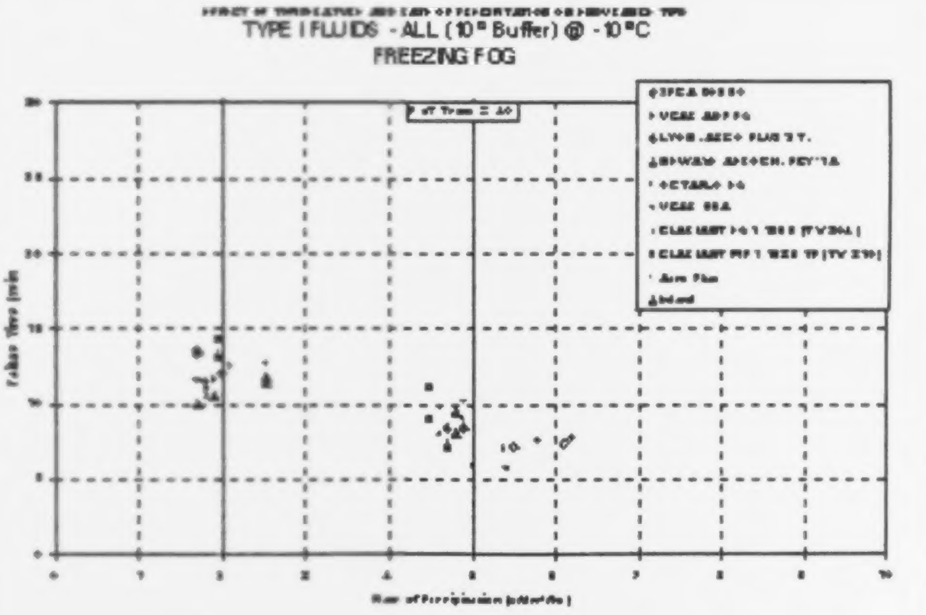
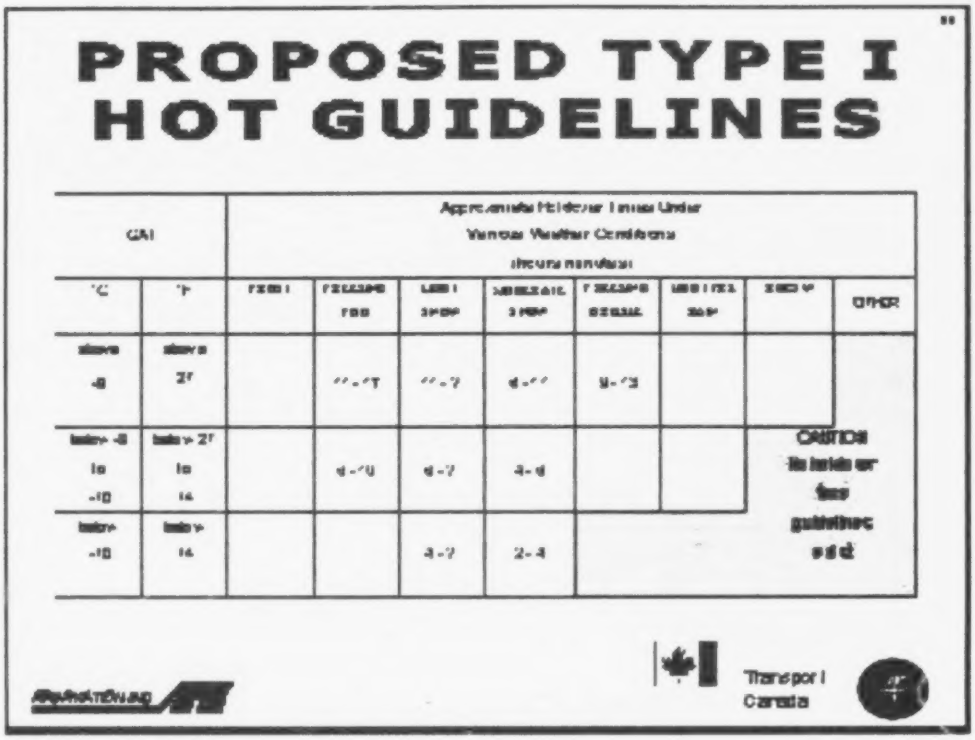


TYPE I FLUIDS - ALL (10° Buffer) @ -10°C

FREEZING FOG



PROPOSED TYPE I HOT GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F	FROST	FREEZING FOG	LIGHT SNOW	MODERATE SNOW	FREEZING DRIZZLE	[illegible]	[illegible]	OTHER
above -3	above 27		11-17	11-?	6-11	9-13			
below -3 to -10	below 27 to 14		6-10	6-?	4-6				CAUTION No holdover time guidelines exist
below -10	below 14			4-7	2-4				

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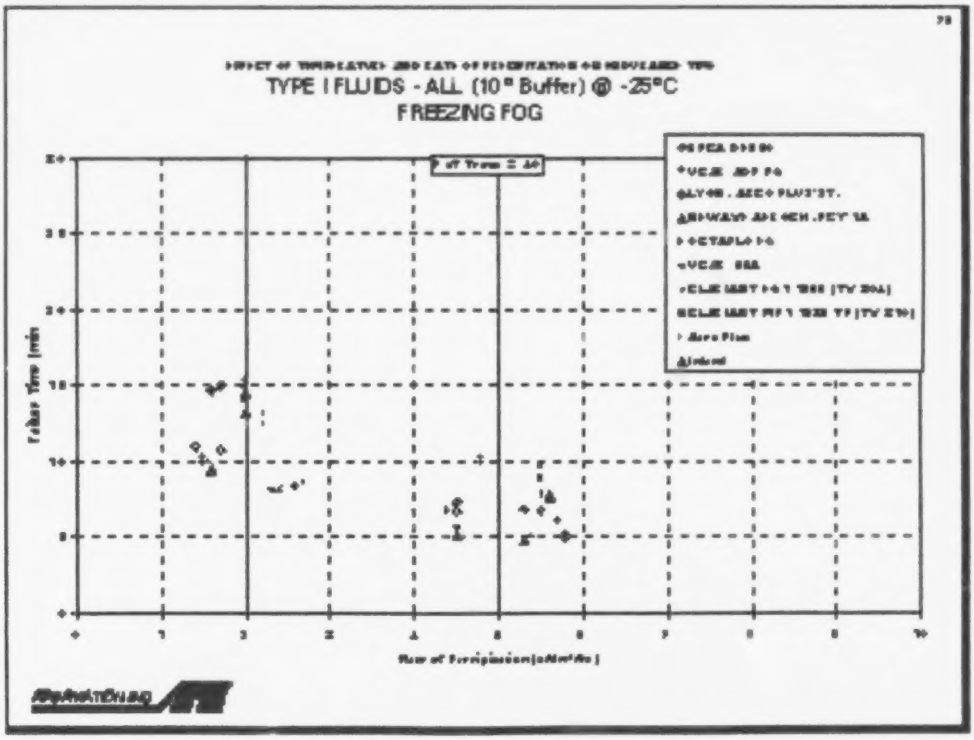

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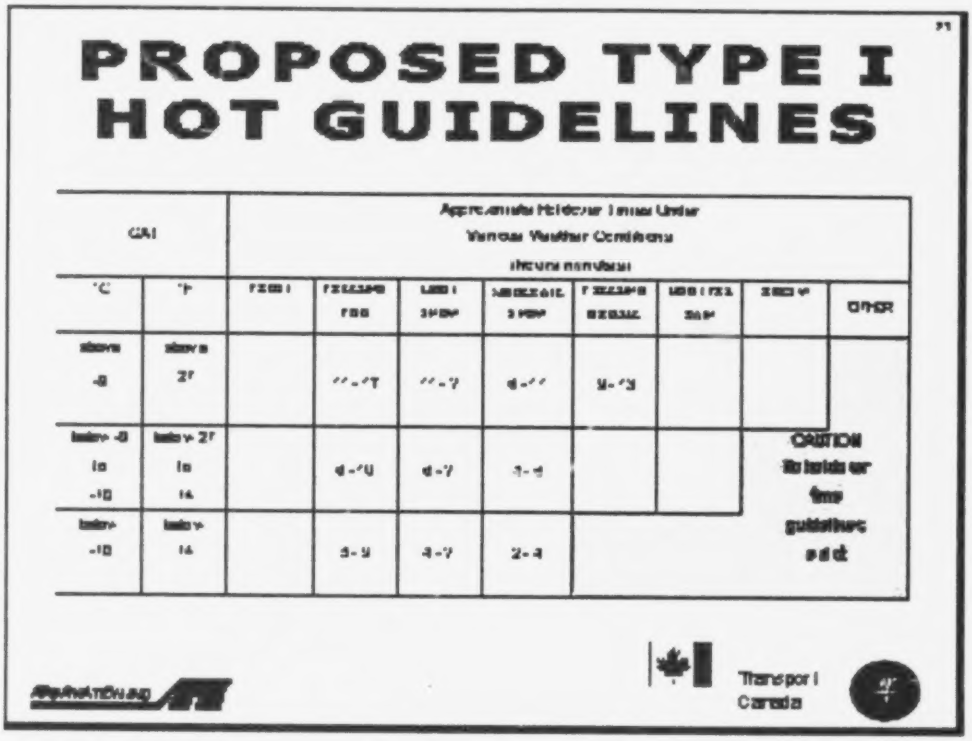
TYPE I FLUIDS - ALL (10° Buffer) @ -25°C

FREEZING FOG



PROPOSED TYPE I HOT GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F	FROST	FREEZING FOG	LIGHT SNOW	MODERATE SNOW	FREEZING DRIZZLE	LIGHT FRZG RAIN	[illegible]	OTHER
above -3	above 27		11-17	11-17	6-11	9-13			
below -3 to -10	below 27 to 14		6-10	6-7	4-6			CAUTION No holdover time guidelines exist	
below -10	below 14		5-9	4-7	2-4				

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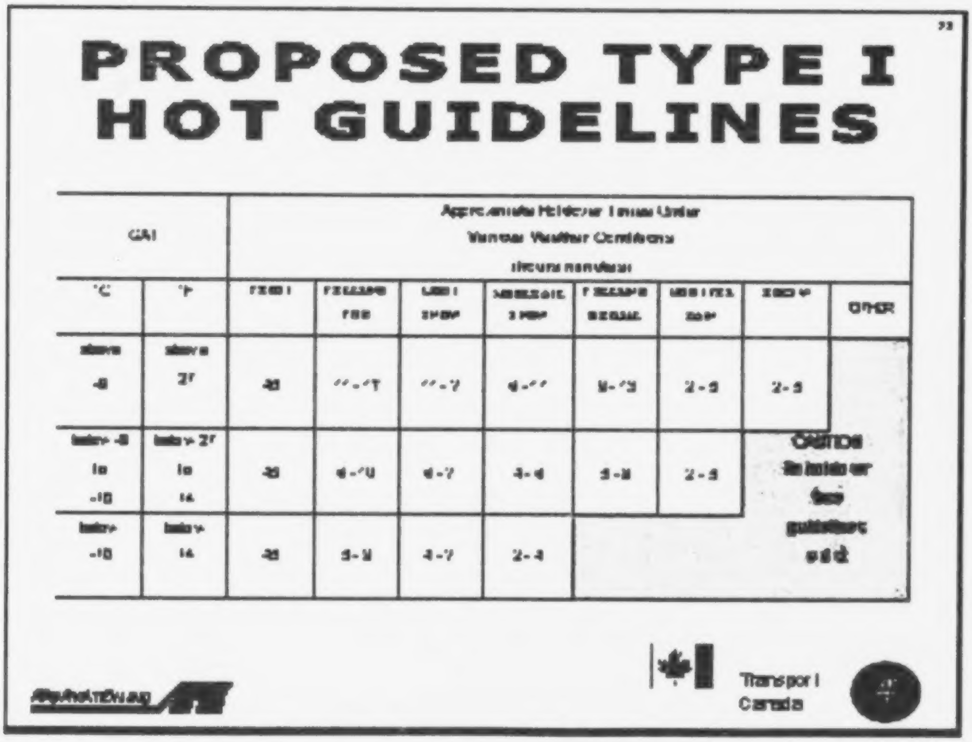

PROPOSED TYPE I HOT GUIDELINES

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
°C	°F	FROST	FREEZING FOG	LIGHT SNOW	MODERATE SNOW	FREEZING DRIZZLE	LIGHT FRZG RAIN	[illegible]	OTHER
above -3	above 27	45	11-17	11-17	6-11	9-13	2-5	2-5	
below -3 to -10	below 27 to 14	45	6-10	6-7	4-6	5-8	2-5	CAUTION No holdover time guidelines exist	
below -10	below 14	45	5-9	4-7	2-4				

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SAE G-12 FUTURE DEICING TECHNOLOGY SUBCOMMITTEE MEETING
FRANKFURT, JUNE 02-07, 2002

FROST CONTAMINATION – COUNTERMEASURE DEVELOPMENT OPPORTUNITIES

by

APS AVIATION INC.

Prepared and Presented on behalf of

Transportation Development Centre
Transport Canada

Transport
Canada

CM1680\Frost Opportunities

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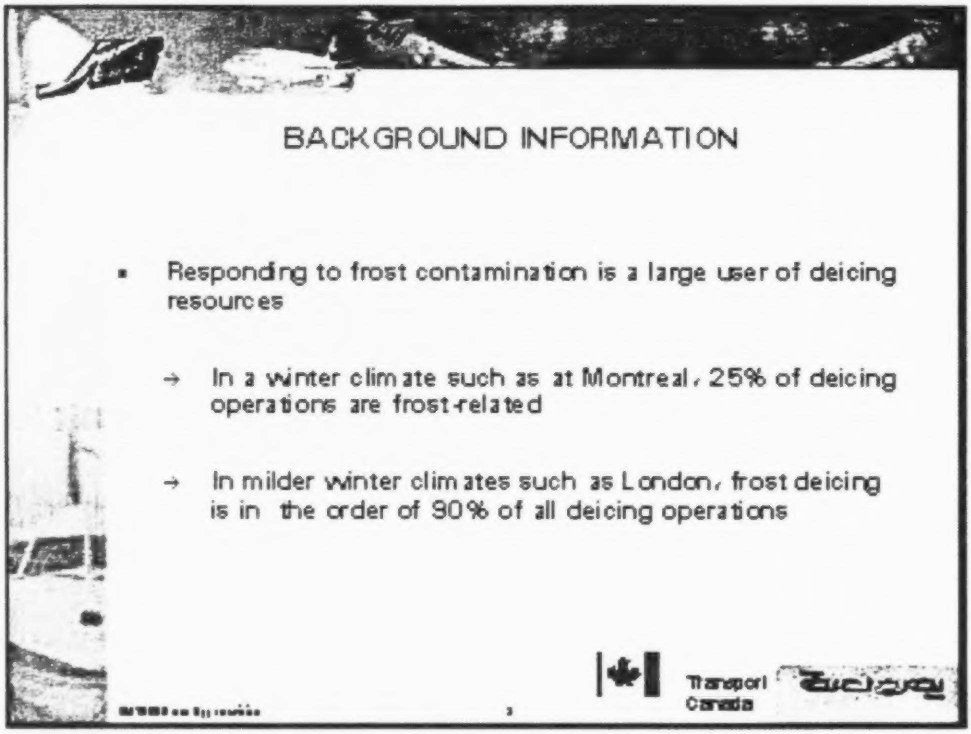

BACKGROUND INFORMATION

- Responding to frost contamination is a large user of deicing resources
  - → In a winter climate such as at Montreal, 25% of deicing operations are frost-related
  - → In milder winter climates such as London, frost deicing is in the order of 90% of all deicing operations

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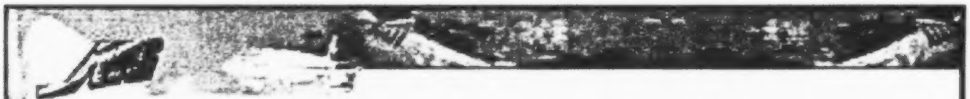

TYPE I FLUID

DISTRIBUTION OF DEICING OPERATIONS

SUMMARY OF ALL AIRPORTS SURVEYED

25900

Total

100.0% of Operations

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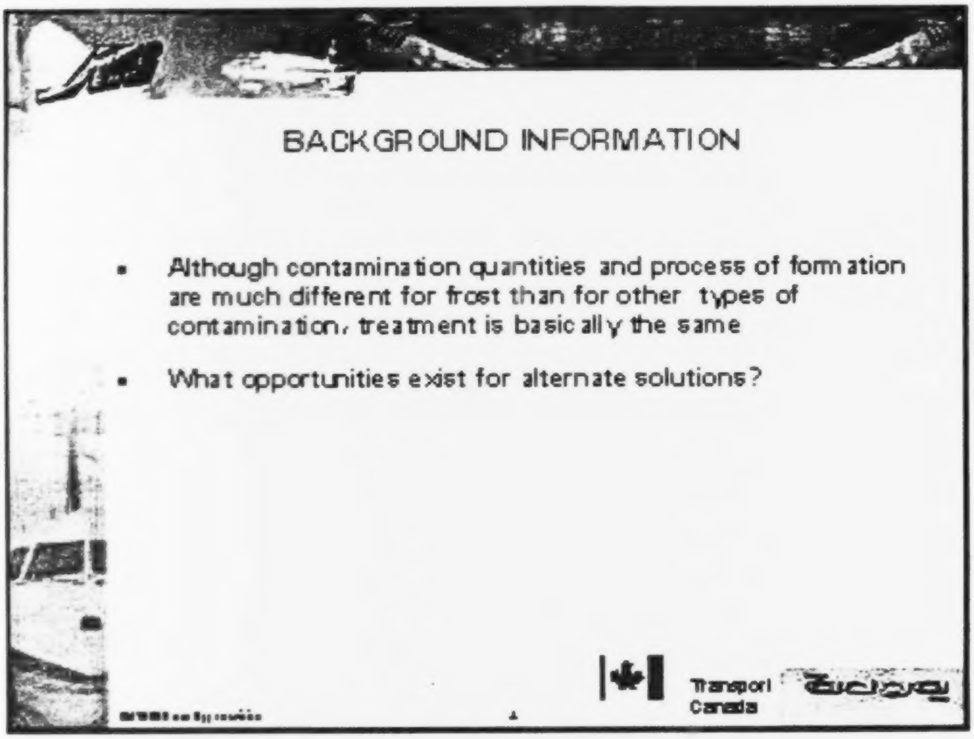

BACKGROUND INFORMATION

- Although contamination quantities and process of formation are much different for frost than for other types of contamination, treatment is basically the same
- What opportunities exist for alternate solutions?

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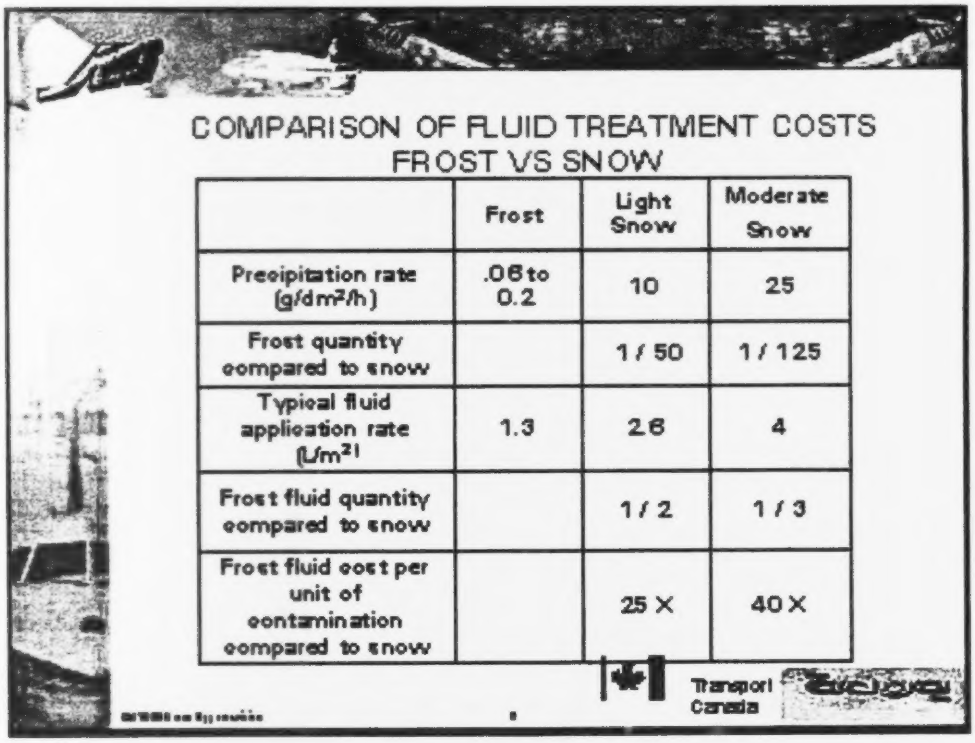

COMPARISON OF FLUID TREATMENT COSTS FROST VS SNOW

	Frost	Light Snow	Moderate Snow
Precipitation rate (g/dm²/h)	.06 to 0.2	10	25
Frost quantity compared to snow		1 / 50	1 / 125
Typical fluid application rate (L/m²)	1.3	2.6	4
Frost fluid quantity compared to snow		1 / 2	1 / 3
Frost fluid cost per unit of contamination compared to snow		25 X	40 X

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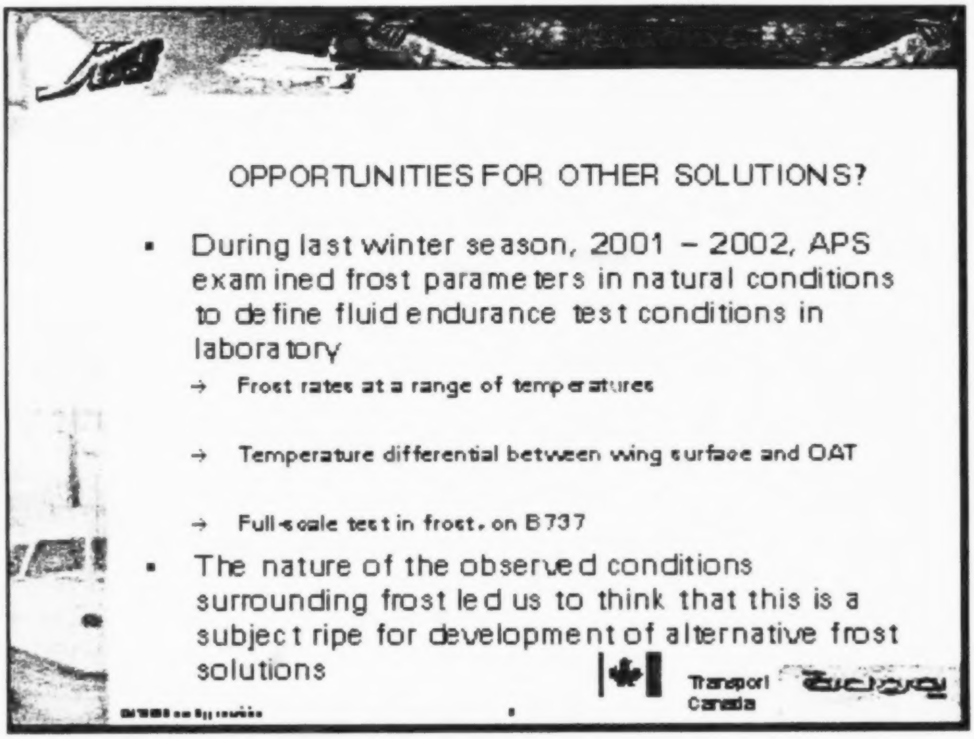

OPPORTUNITIES FOR OTHER SOLUTIONS?

- During last winter season, 2001 – 2002, APS examined frost parameters in natural conditions to define fluid endurance test conditions in laboratory
  - → Frost rates at a range of temperatures
  - → Temperature differential between wing surface and OAT
  - → Full-scale test in frost, on B737
- The nature of the observed conditions surrounding frost led us to think that this is a subject ripe for development of alternative frost solutions

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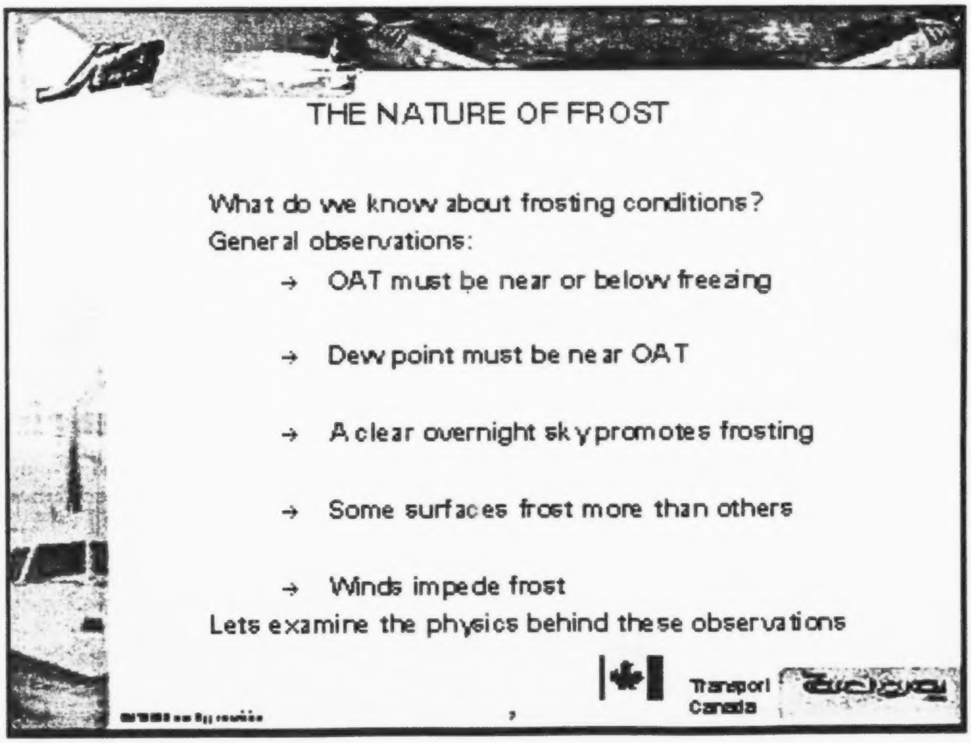

THE NATURE OF FROST

What do we know about frosting conditions?

General observations:

- → OAT must be near or below freezing
- → Dew point must be near OAT
- → A clear overnight sky promotes frosting
- → Some surfaces frost more than others
- → Winds impede frost

Lets examine the physics behind these observations

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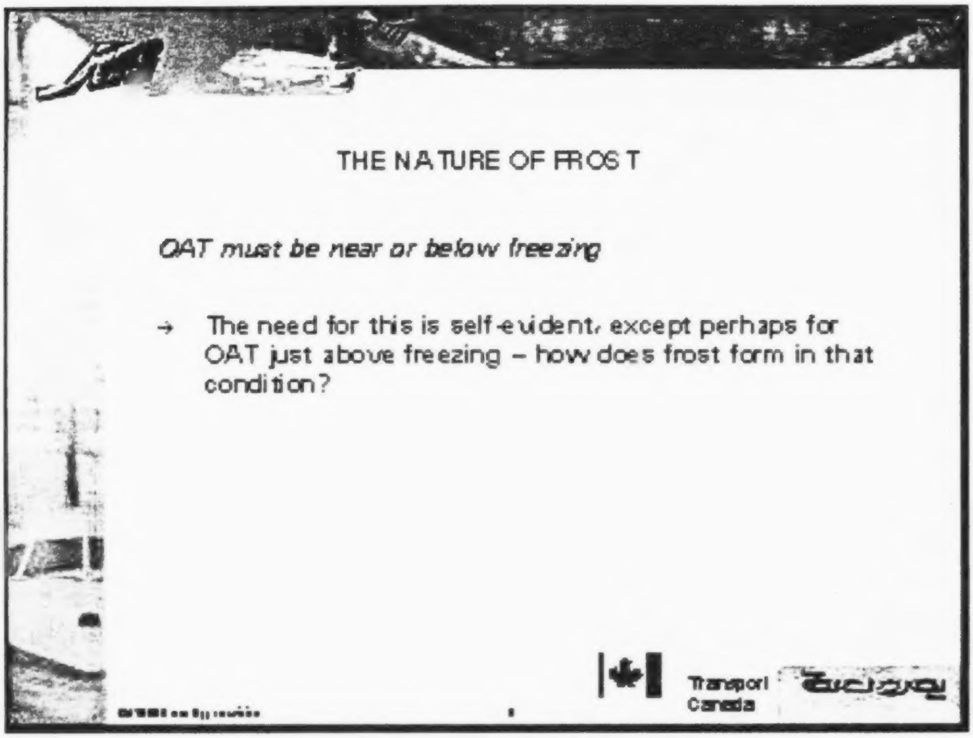

THE NATURE OF FROST

OAT must be near or below freezing

→ The need for this is self-evident, except perhaps for OAT just above freezing – how does frost form in that condition?

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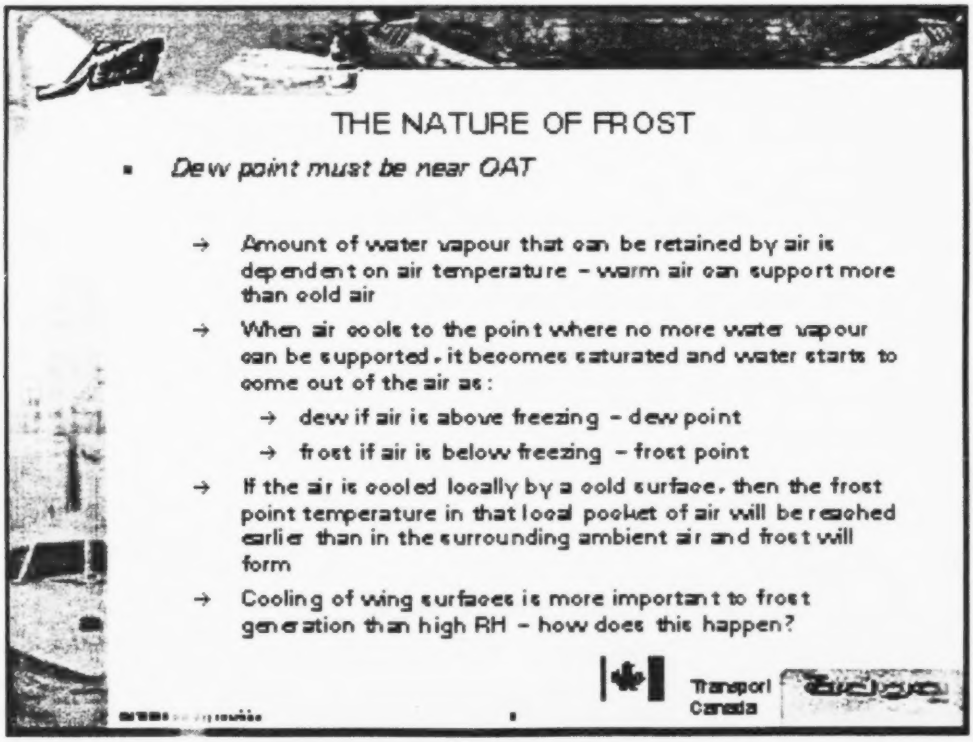

THE NATURE OF FROST

- *Dew point must be near OAT*
  - → Amount of water vapour that can be retained by air is dependent on air temperature – warm air can support more than cold air
  - → When air cools to the point where no more water vapour can be supported, it becomes saturated and water starts to come out of the air as:
    - → dew if air is above freezing – dew point
    - → frost if air is below freezing – frost point
  - → If the air is cooled locally by a cold surface, then the frost point temperature in that local pocket of air will be reached earlier than in the surrounding ambient air and frost will form
  - → Cooling of wing surfaces is more important to frost generation than high RH – how does this happen?

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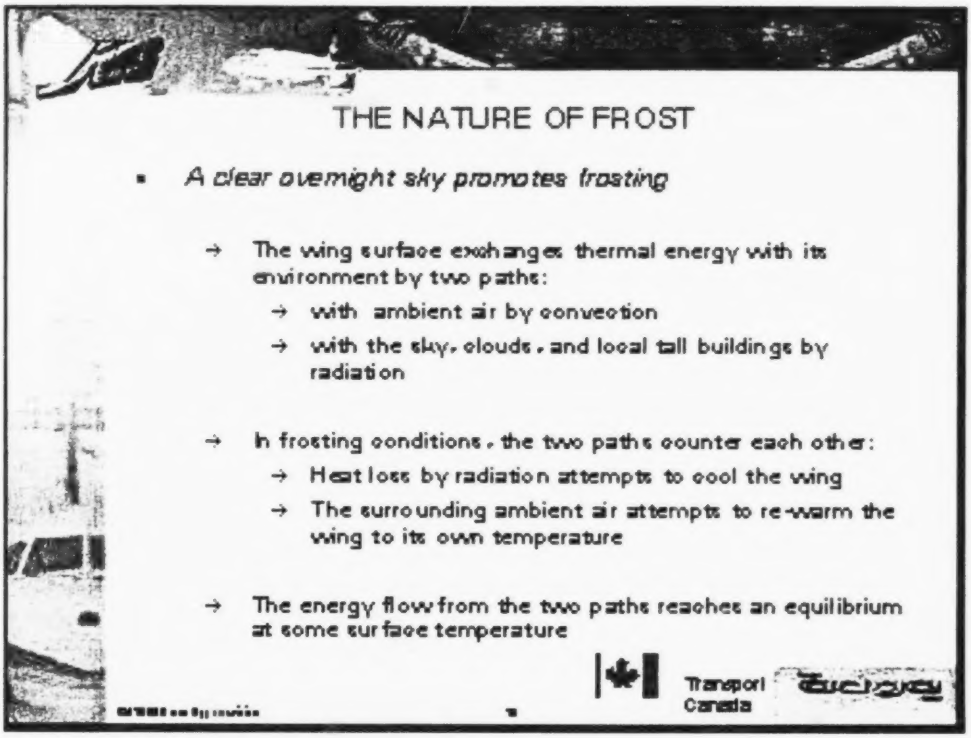

THE NATURE OF FROST

- *A clear overnight sky promotes frosting*

→ The wing surface exchanges thermal energy with its environment by two paths:

  → with ambient air by convection

  → with the sky, clouds, and local tall buildings by radiation

→ In frosting conditions, the two paths counter each other:

  → Heat loss by radiation attempts to cool the wing

  → The surrounding ambient air attempts to re-warm the wing to its own temperature

→ The energy flow from the two paths reaches an equilibrium at some surface temperature

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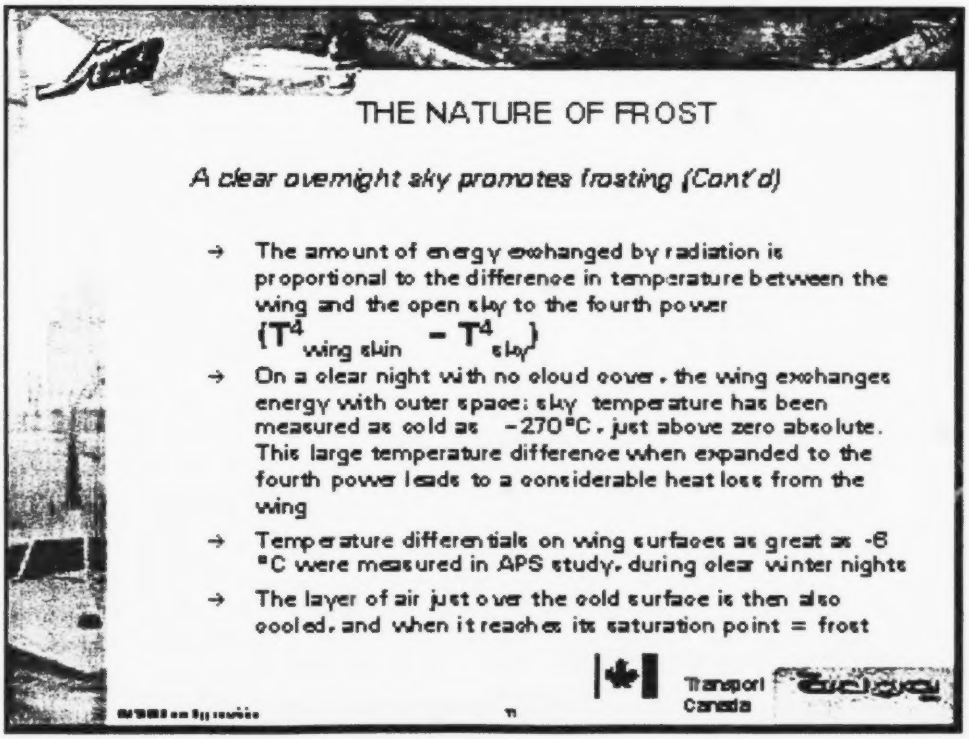

THE NATURE OF FROST

A clear overnight sky promotes frosting (Cont'd)

→ The amount of energy exchanged by radiation is proportional to the difference in temperature between the wing and the open sky to the fourth power $(T^4_{\text{wing skin}} - T^4_{\text{sky}})$

→ On a clear night with no cloud cover, the wing exchanges energy with outer space; sky temperature has been measured as cold as -270°C, just above zero absolute. This large temperature difference when expanded to the fourth power leads to a considerable heat loss from the wing

→ Temperature differentials on wing surfaces as great as -6 °C were measured in APS study, during clear winter nights

→ The layer of air just over the cold surface is then also cooled, and when it reaches its saturation point = frost

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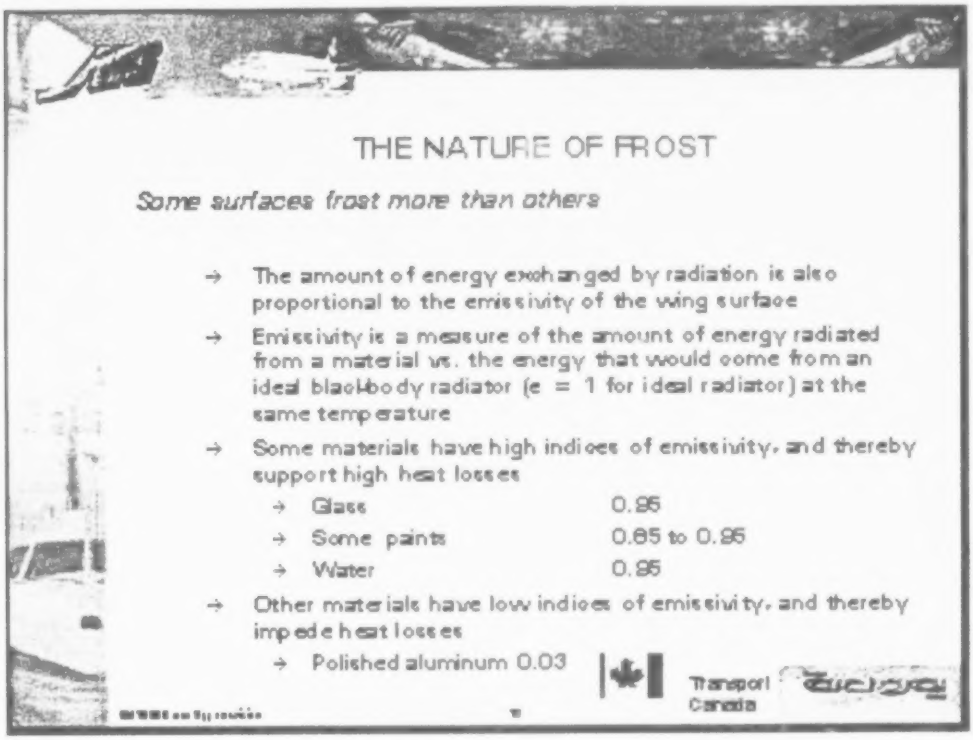

THE NATURE OF FROST

Some surfaces frost more than others

- The amount of energy exchanged by radiation is also proportional to the emissivity of the wing surface
- Emissivity is a measure of the amount of energy radiated from a material vs. the energy that would come from an ideal black-body radiator (e = 1 for ideal radiator) at the same temperature
- Some materials have high indices of emissivity, and thereby support high heat losses
  - Glass 0.95
  - Some paints 0.85 to 0.95
  - Water 0.95
- Other materials have low indices of emissivity, and thereby impede heat losses
  - Polished aluminum 0.03

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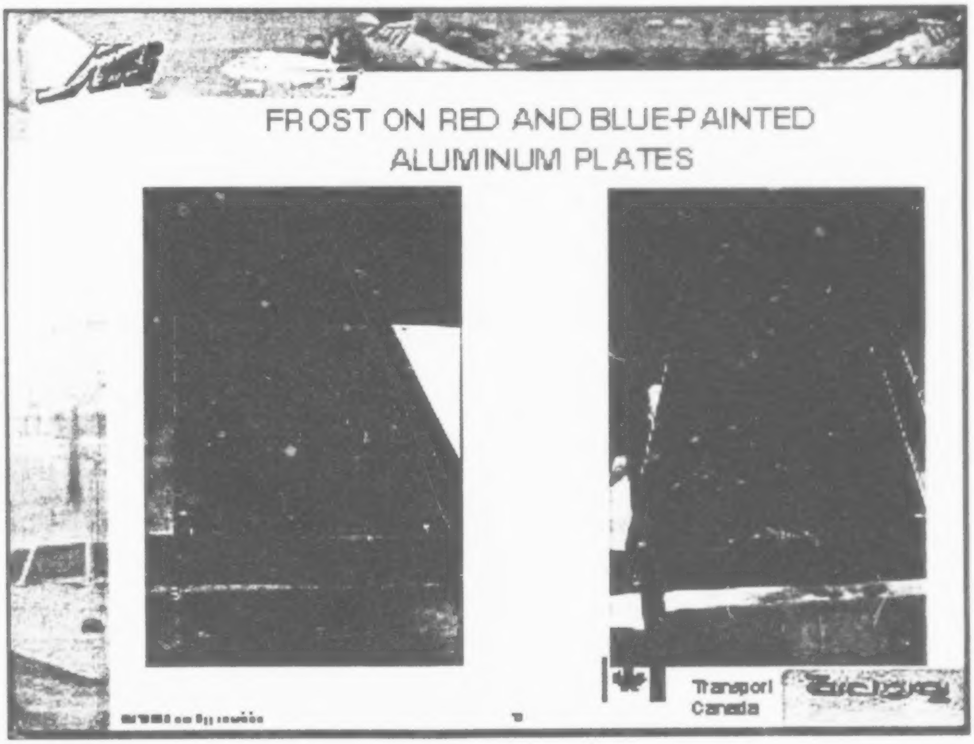

FROST ON RED AND BLUE-PAINTED ALUMINUM PLATES

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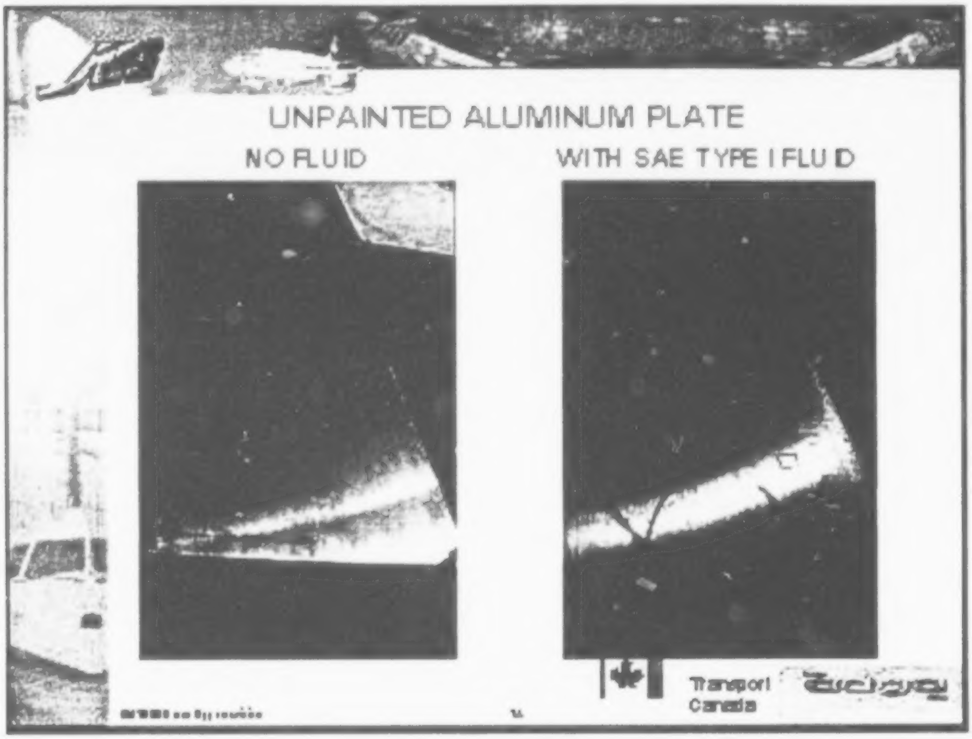

UNPAINTED ALUMINUM PLATE

NO FLUID

WITH SAE TYPE I FLUID

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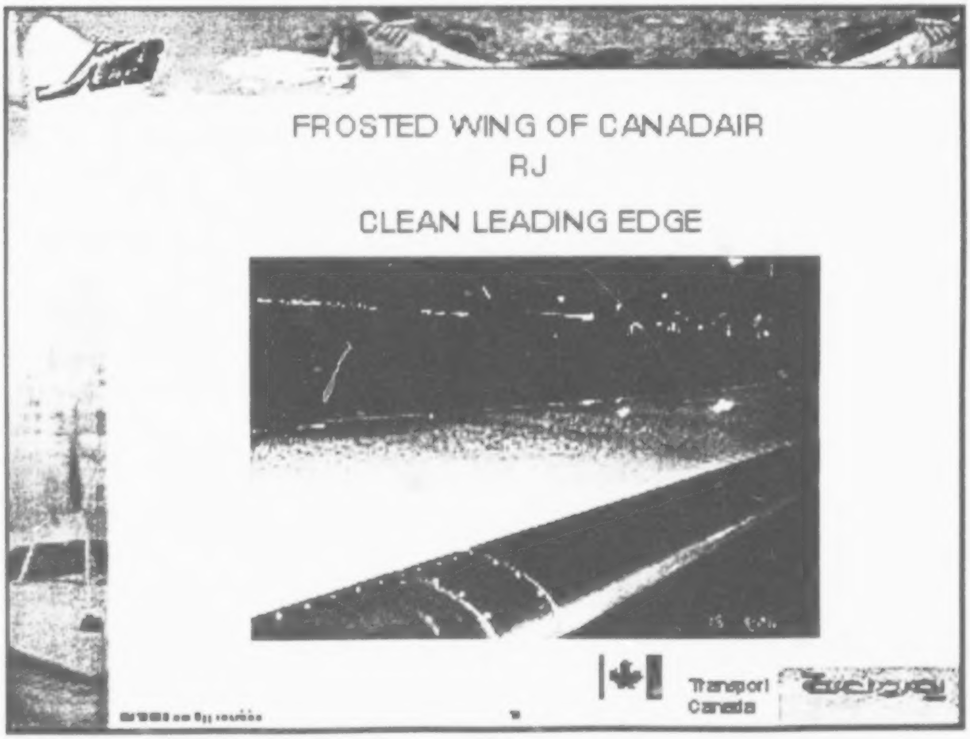

FROSTED WING OF CANADAIR RJ

CLEAN LEADING EDGE

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FROSTED WING OF CANADAIR
RJ

CLEAN LEADING EDGE

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FULL-SCALE FROST TEST B737

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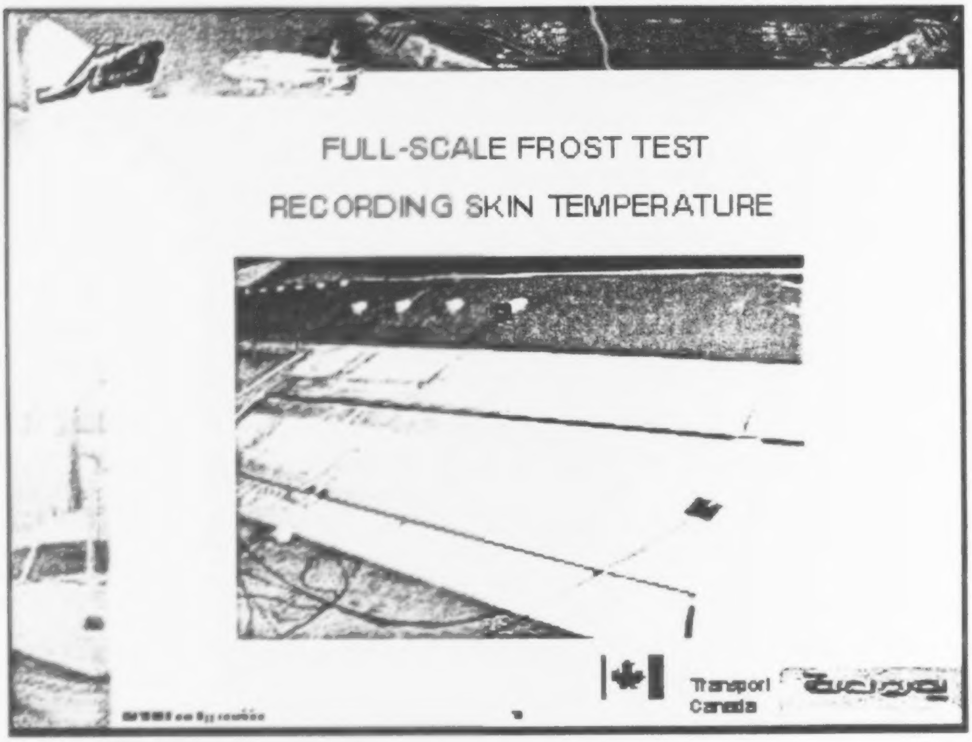

FULL-SCALE FROST TEST

RECORDING SKIN TEMPERATURE

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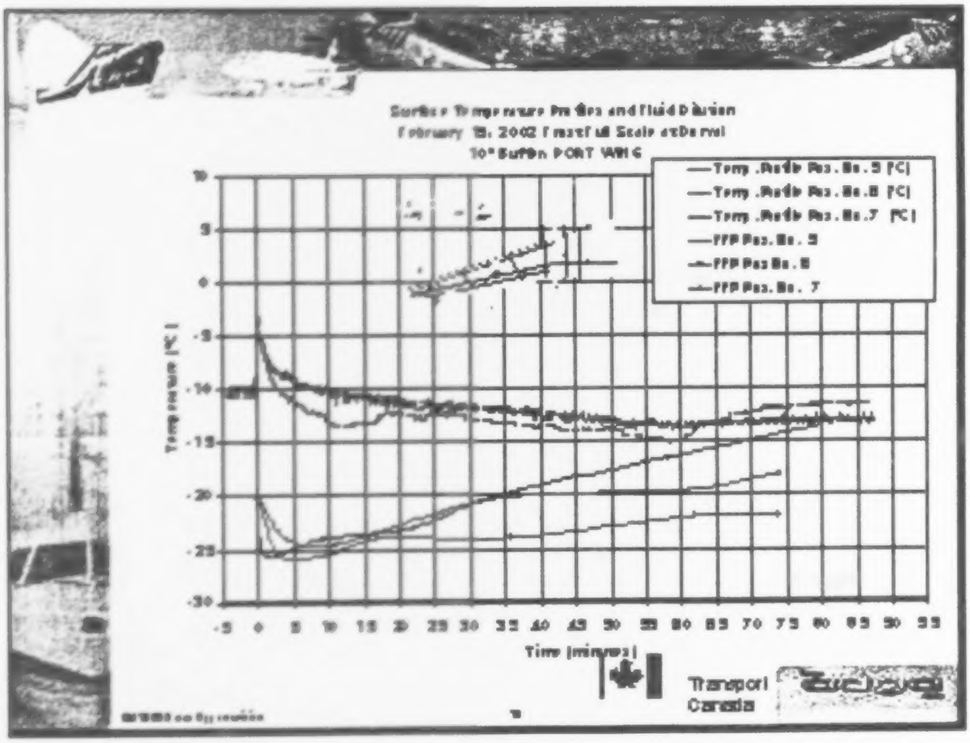

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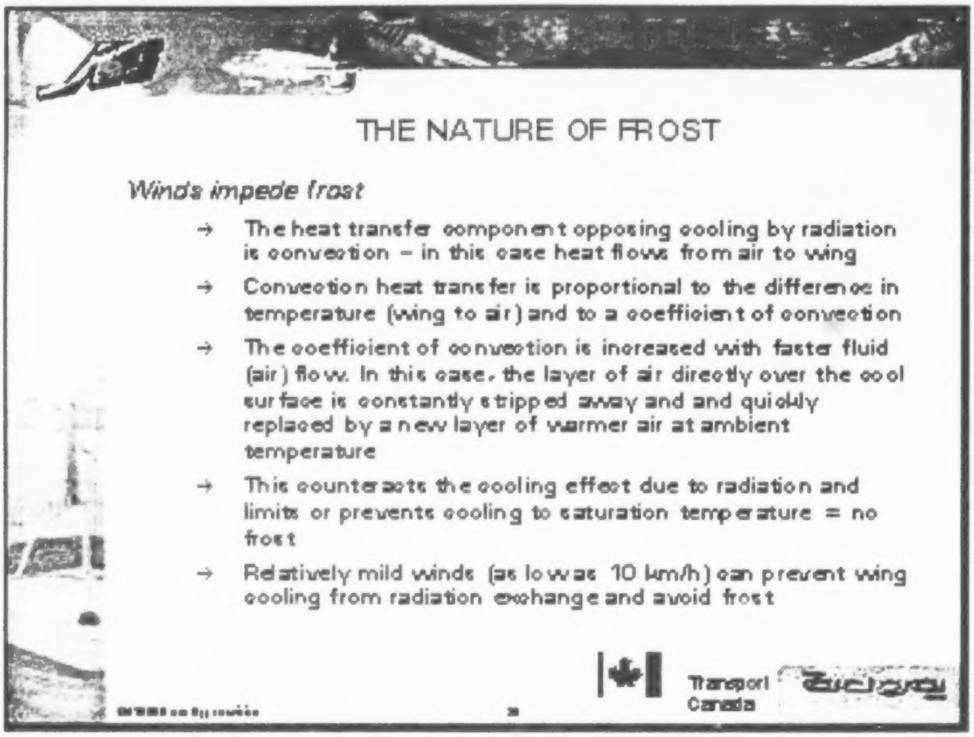

THE NATURE OF FROST

Winds impede frost

- → The heat transfer component opposing cooling by radiation is convection – in this case heat flows from air to wing
- → Convection heat transfer is proportional to the difference in temperature (wing to air) and to a coefficient of convection
- → The coefficient of convection is increased with faster fluid (air) flow. In this case, the layer of air directly over the cool surface is constantly stripped away and and quickly replaced by a new layer of warmer air at ambient temperature
- → This counteracts the cooling effect due to radiation and limits or prevents cooling to saturation temperature = no frost
- → Relatively mild winds (as low as 10 km/h) can prevent wing cooling from radiation exchange and avoid frost

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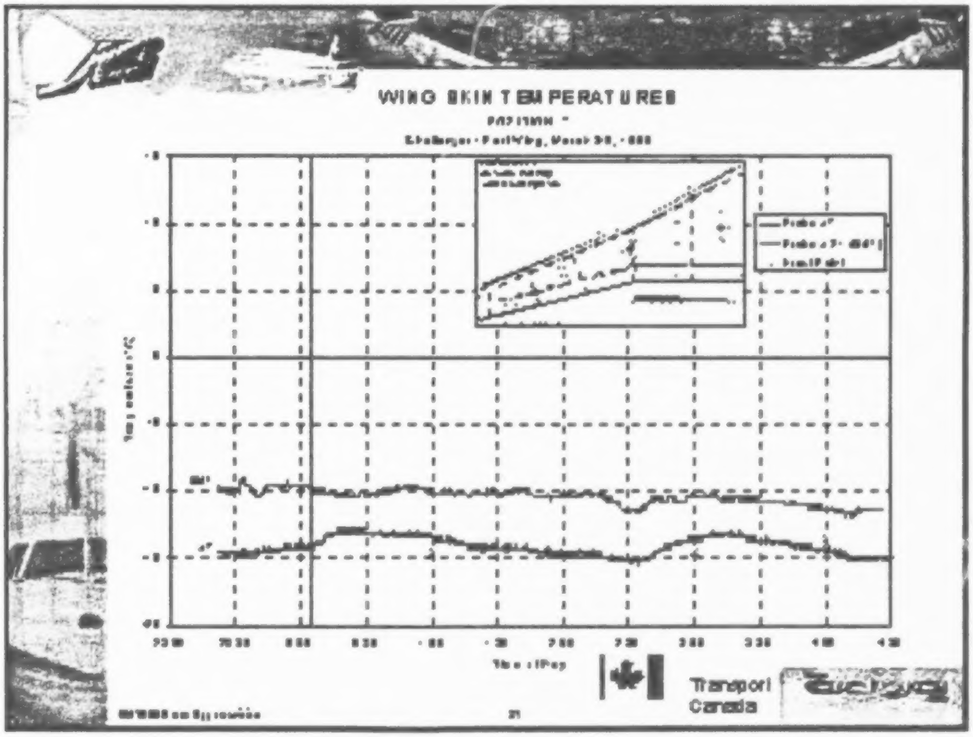
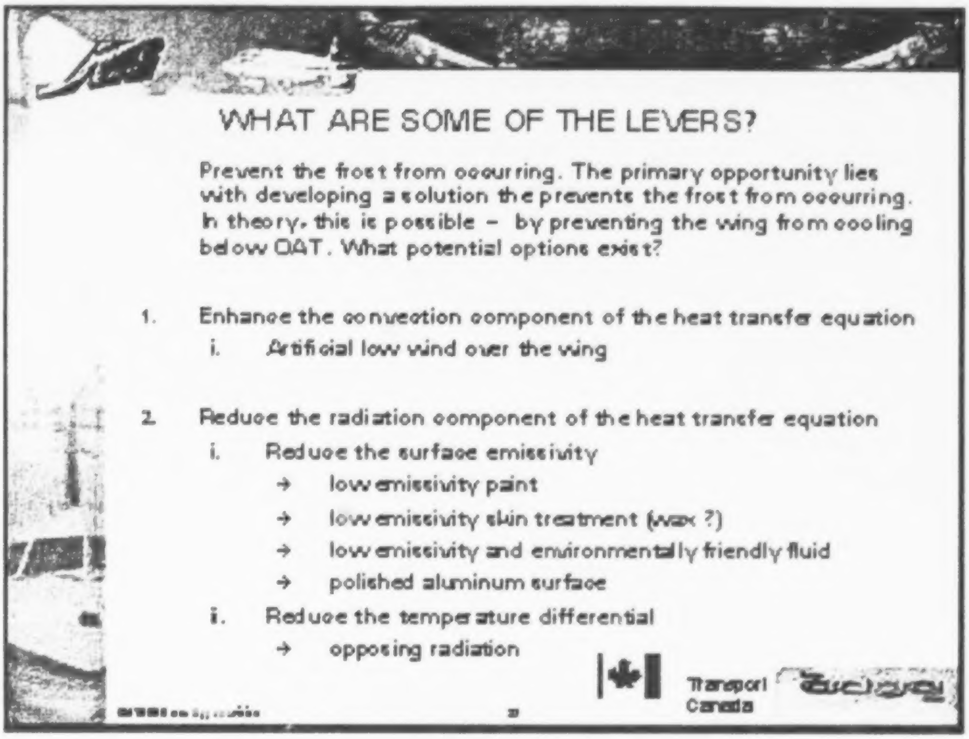


WING SKIN TEMPERATURES



WHAT ARE SOME OF THE LEVERS?

Prevent the frost from occurring. The primary opportunity lies with developing a solution the prevents the frost from occurring. In theory, this is possible – by preventing the wing from cooling below OAT. What potential options exist?

1. Enhance the convection component of the heat transfer equation
    - i. Artificial low wind over the wing

2. Reduce the radiation component of the heat transfer equation
    - i. Reduce the surface emissivity
        - → low emissivity paint
        - → low emissivity skin treatment (wax ?)
        - → low emissivity and environmentally friendly fluid
        - → polished aluminum surface
    - i. Reduce the temperature differential
        - → opposing radiation

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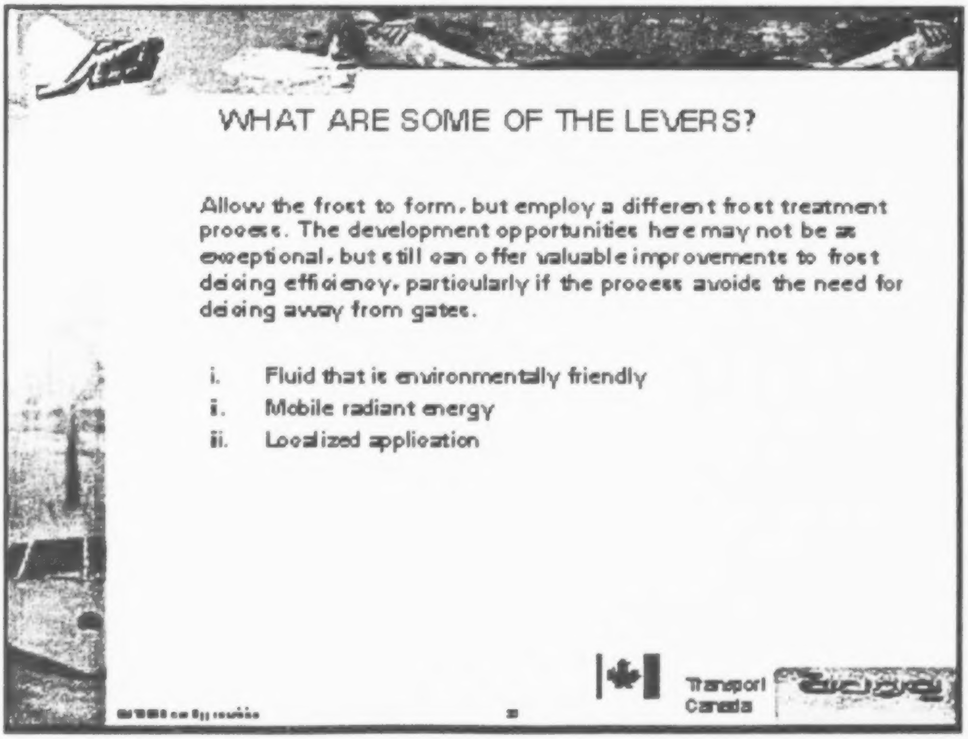

WHAT ARE SOME OF THE LEVERS?

Allow the frost to form, but employ a different frost treatment process. The development opportunities here may not be as exceptional, but still can offer valuable improvements to frost deicing efficiency, particularly if the process avoids the need for deicing away from gates.

i. Fluid that is environmentally friendly
i. Mobile radiant energy
ii. Localized application

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SAE G-12 EQUIPMENT SUBCOMMITTEE MEETING
FRANKFURT, JUNE 02-07, 2002

TEST PROGRAM - FORCED AIR SYSTEMS
TYPE II / IV FLUID *APPLIED OVER*
or *INJECTED INTO* THE FORCED AIR STREAM

by

APS AVIATION INC.

Supported by

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
William J. Hughes Technical Centre

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CM1680\Eqpt subcomm - type II or IV

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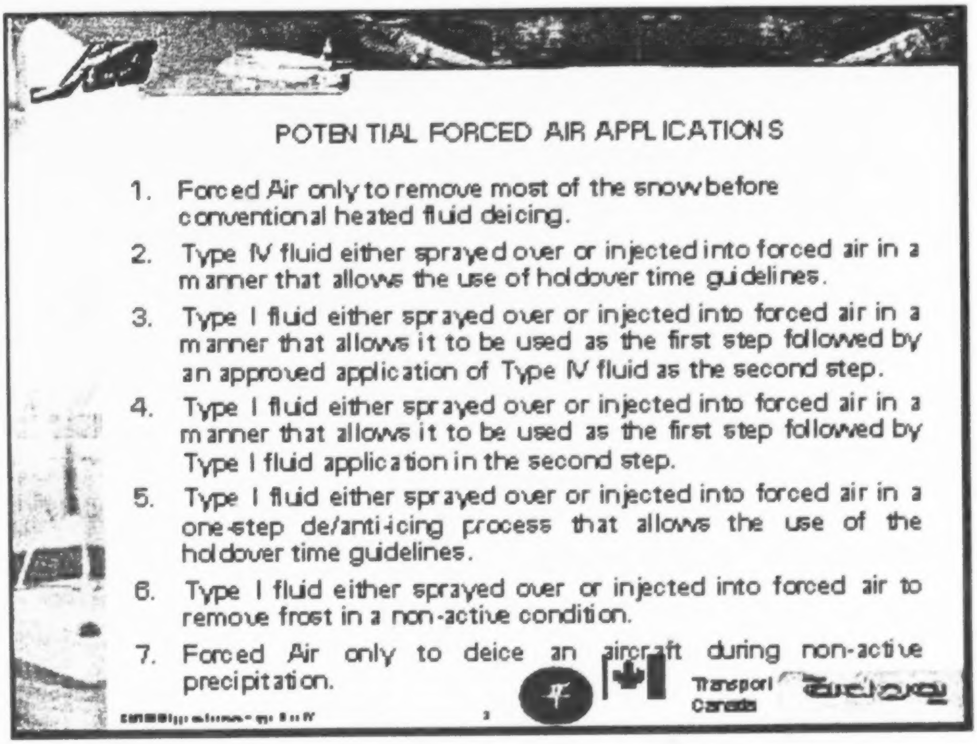

POTENTIAL FORCED AIR APPLICATIONS

1. Forced Air only to remove most of the snow before conventional heated fluid deicing.
2. Type IV fluid either sprayed over or injected into forced air in a manner that allows the use of holdover time guidelines.
3. Type I fluid either sprayed over or injected into forced air in a manner that allows it to be used as the first step followed by an approved application of Type IV fluid as the second step.
4. Type I fluid either sprayed over or injected into forced air in a manner that allows it to be used as the first step followed by Type I fluid application in the second step.
5. Type I fluid either sprayed over or injected into forced air in a one-step de/anti-icing process that allows the use of the holdover time guidelines.
6. Type I fluid either sprayed over or injected into forced air to remove frost in a non-active condition.
7. Forced Air only to deice an aircraft during non-active precipitation.

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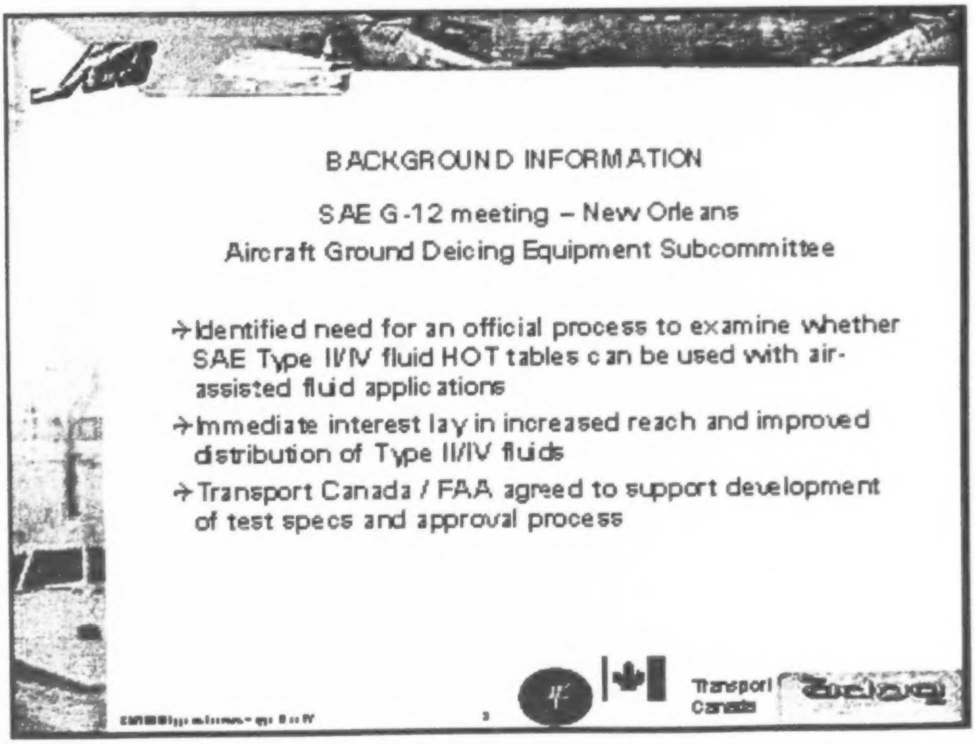

BACKGROUND INFORMATION

SAE G-12 meeting – New Orleans

Aircraft Ground Deicing Equipment Subcommittee

- → Identified need for an official process to examine whether SAE Type II/IV fluid HOT tables can be used with air-assisted fluid applications
- → Immediate interest lay in increased reach and improved distribution of Type II/IV fluids
- → Transport Canada / FAA agreed to support development of test specs and approval process

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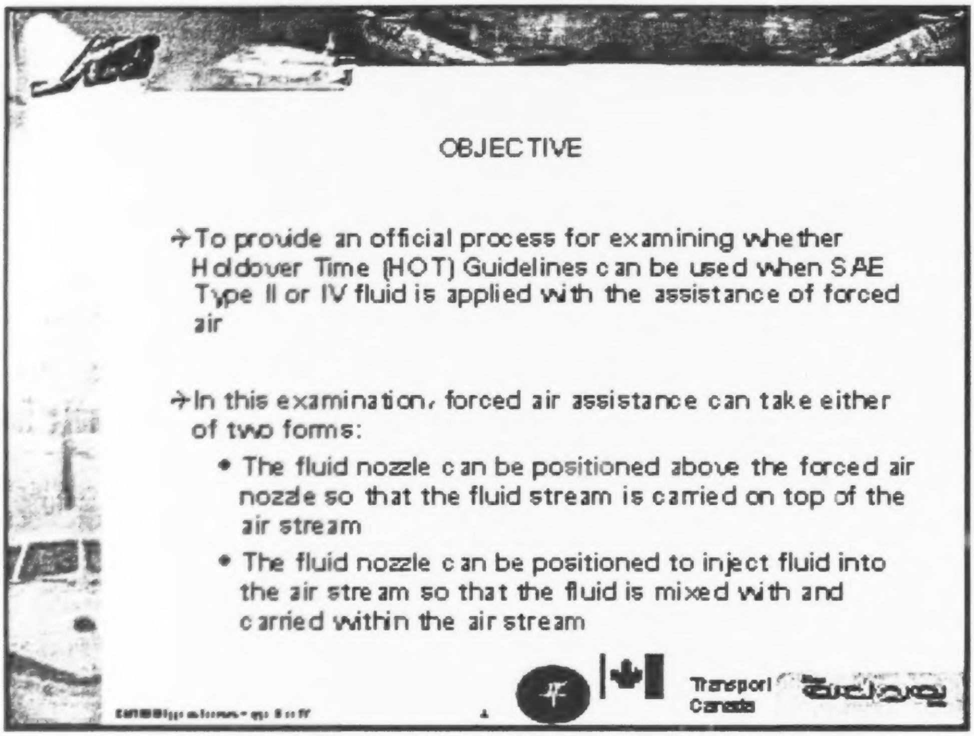

OBJECTIVE

→ To provide an official process for examining whether Holdover Time (HOT) Guidelines can be used when SAE Type II or IV fluid is applied with the assistance of forced air

→ In this examination, forced air assistance can take either of two forms:
  - The fluid nozzle can be positioned above the forced air nozzle so that the fluid stream is carried on top of the air stream
  - The fluid nozzle can be positioned to inject fluid into the air stream so that the fluid is mixed with and carried within the air stream

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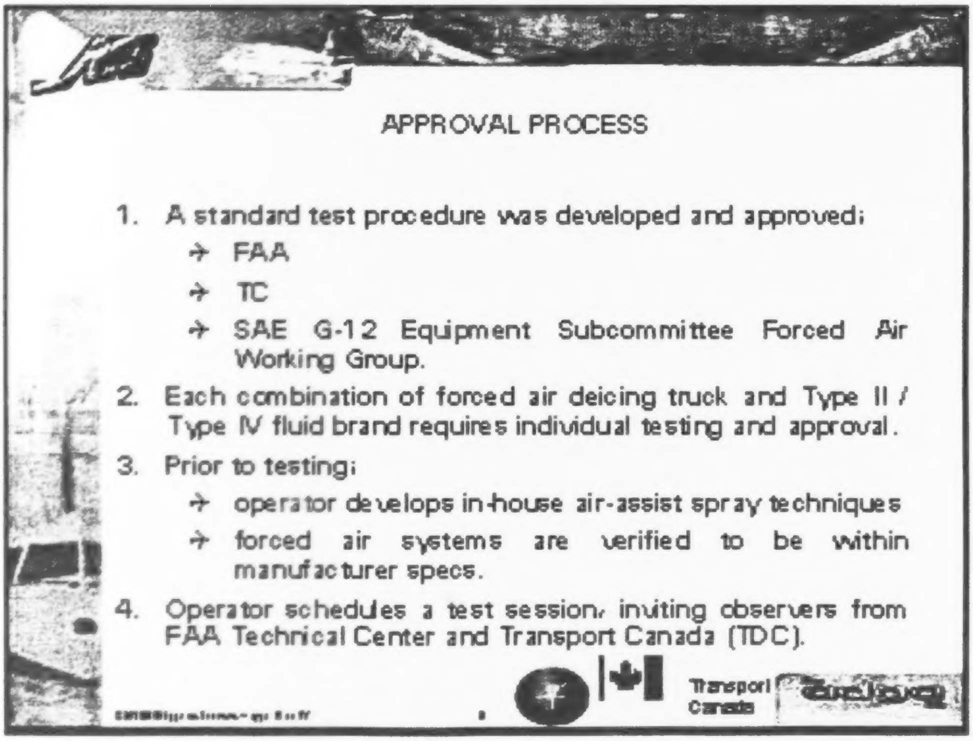

APPROVAL PROCESS

1. A standard test procedure was developed and approved;
   - → FAA
   - → TC
   - → SAE G-12 Equipment Subcommittee Forced Air Working Group.
2. Each combination of forced air deicing truck and Type II / Type IV fluid brand requires individual testing and approval.
3. Prior to testing;
   - → operator develops in-house air-assist spray techniques
   - → forced air systems are verified to be within manufacturer specs.
4. Operator schedules a test session, inviting observers from FAA Technical Center and Transport Canada (TDC).

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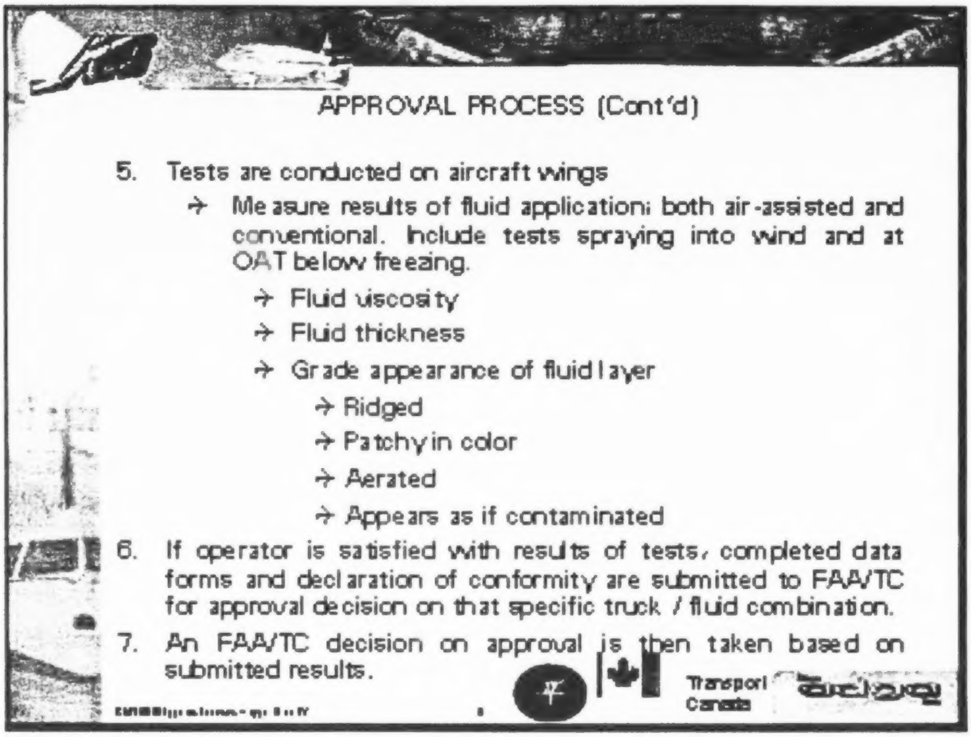

APPROVAL PROCESS (Cont'd)

5. Tests are conducted on aircraft wings
    - Measure results of fluid application: both air-assisted and conventional. Include tests spraying into wind and at OAT below freezing.
        - Fluid viscosity
        - Fluid thickness
        - Grade appearance of fluid layer
            - Ridged
            - Patchy in color
            - Aerated
            - Appears as if contaminated
6. If operator is satisfied with results of tests, completed data forms and declaration of conformity are submitted to FAA/TC for approval decision on that specific truck / fluid combination.
7. An FAA/TC decision on approval is then taken based on submitted results.

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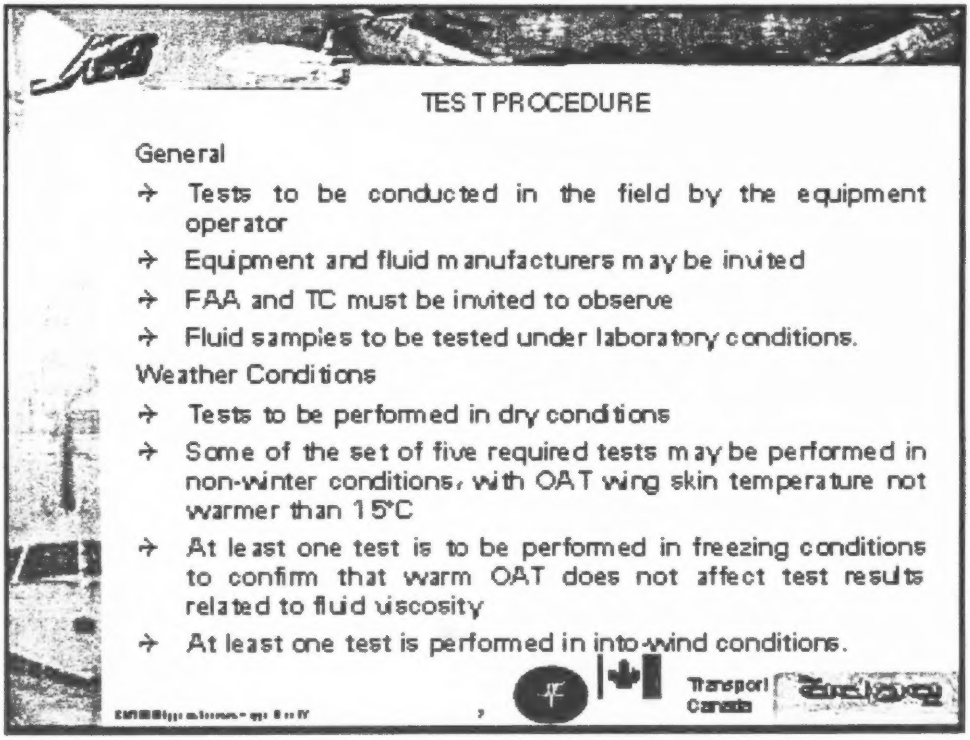

TEST PROCEDURE

General

- Tests to be conducted in the field by the equipment operator
- Equipment and fluid manufacturers may be invited
- FAA and TC must be invited to observe
- Fluid samples to be tested under laboratory conditions.

Weather Conditions

- Tests to be performed in dry conditions
- Some of the set of five required tests may be performed in non-winter conditions, with OAT wing skin temperature not warmer than 15°C
- At least one test is to be performed in freezing conditions to confirm that warm OAT does not affect test results related to fluid viscosity
- At least one test is performed in into-wind conditions.

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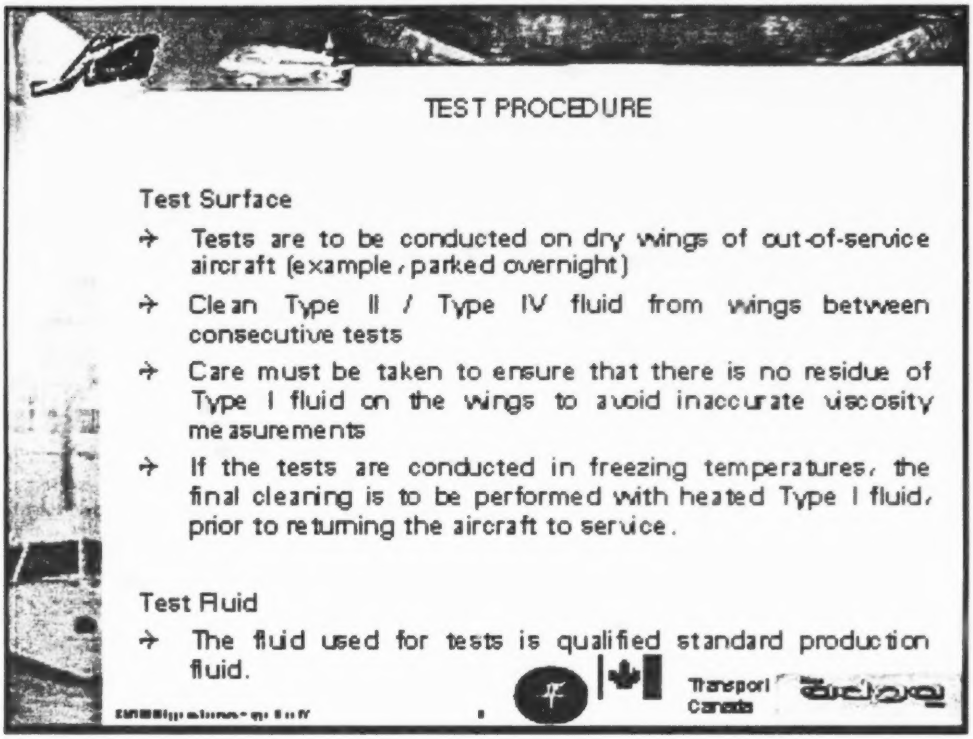

TEST PROCEDURE

Test Surface

- Tests are to be conducted on dry wings of out-of-service aircraft (example, parked overnight)
- Clean Type II / Type IV fluid from wings between consecutive tests
- Care must be taken to ensure that there is no residue of Type I fluid on the wings to avoid inaccurate viscosity measurements
- If the tests are conducted in freezing temperatures, the final cleaning is to be performed with heated Type I fluid, prior to returning the aircraft to service.

Test Fluid

- The fluid used for tests is qualified standard production fluid.

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TEST PROCEDURE

TEST EQUIPMENT CHECKLIST
TRIALS FOR TYPE II / TYPE IV FLUID APPLIED OVER
or INJECTED INTO THE FORCED AIR STREAM

TASK	STATUS
Logistics For Every Test Session	
Schedule test with truck and fluid manufacturer	
Advise FAA, TDC	
Arrange for test aircraft	
Test Equipment	
Forced air deicing truck	
Test procedure	
Data Forms	
Clipboards	
Pencils	
Wipes / rags	
Fluid thickness gauges	
Fluid sample containers with labels (24)	
Plastic to pick up fluid samples from wing	
Lighting for stands	
Access stands to observe at wing	
Flashlights	

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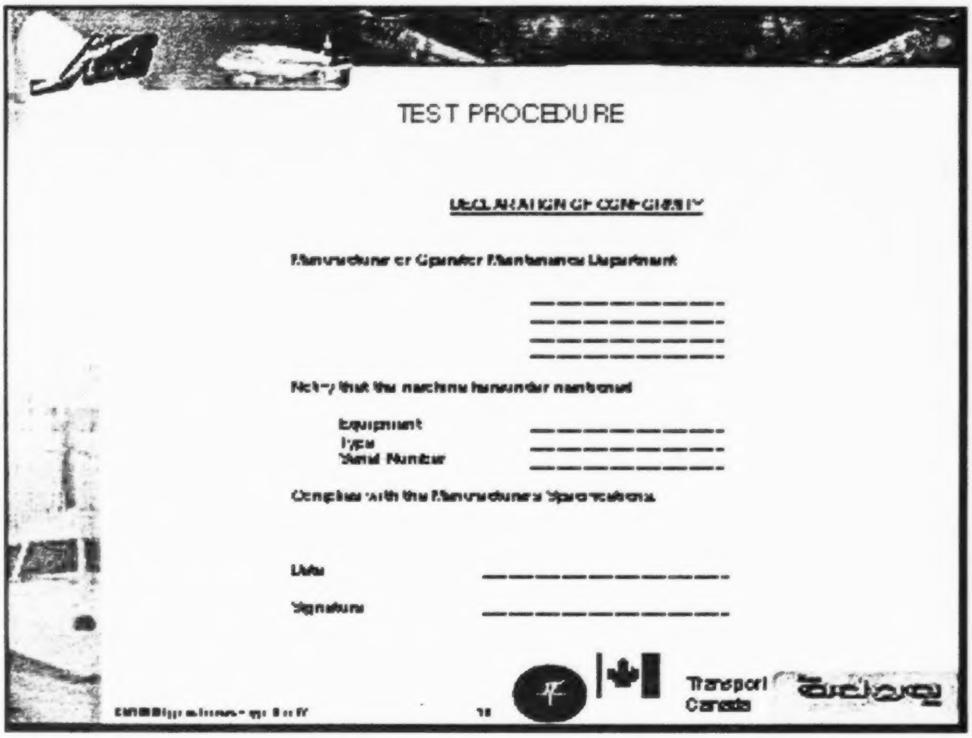

TEST PROCEDURE

DECLARATION OF CONFORMITY

Manufacturer or Operator Maintenance Department

Notify that the machine hereunder mentioned

Equipment ____________
Type ____________
Serial Number ____________

Complies with the Manufacturer's Specifications

Date ____________

Signature ____________

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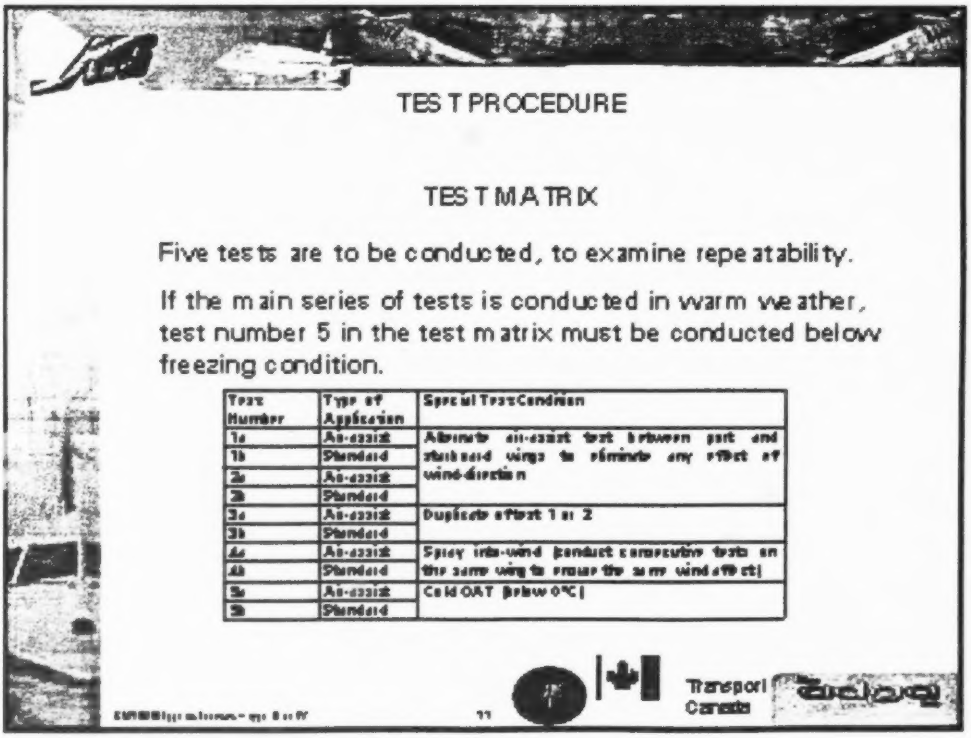

TEST PROCEDURE

TEST MATRIX

Five tests are to be conducted, to examine repeatability.

If the main series of tests is conducted in warm weather, test number 5 in the test matrix must be conducted below freezing condition.

Test Number	Type of Application	Special Test Condition
1a	Air-assist	Alternate air-assist test between port and starboard wings to eliminate any effect of wind direction
1b	Standard	
2a	Air-assist	
2b	Standard	
3a	Air-assist	Duplicate of test 1 or 2
3b	Standard	
4a	Air-assist	Spray into-wind (conduct consecutive tests on the same wing to ensure the same wind effect)
4b	Standard	
5a	Air-assist	Cold OAT (below 0°C)
5b	Standard	

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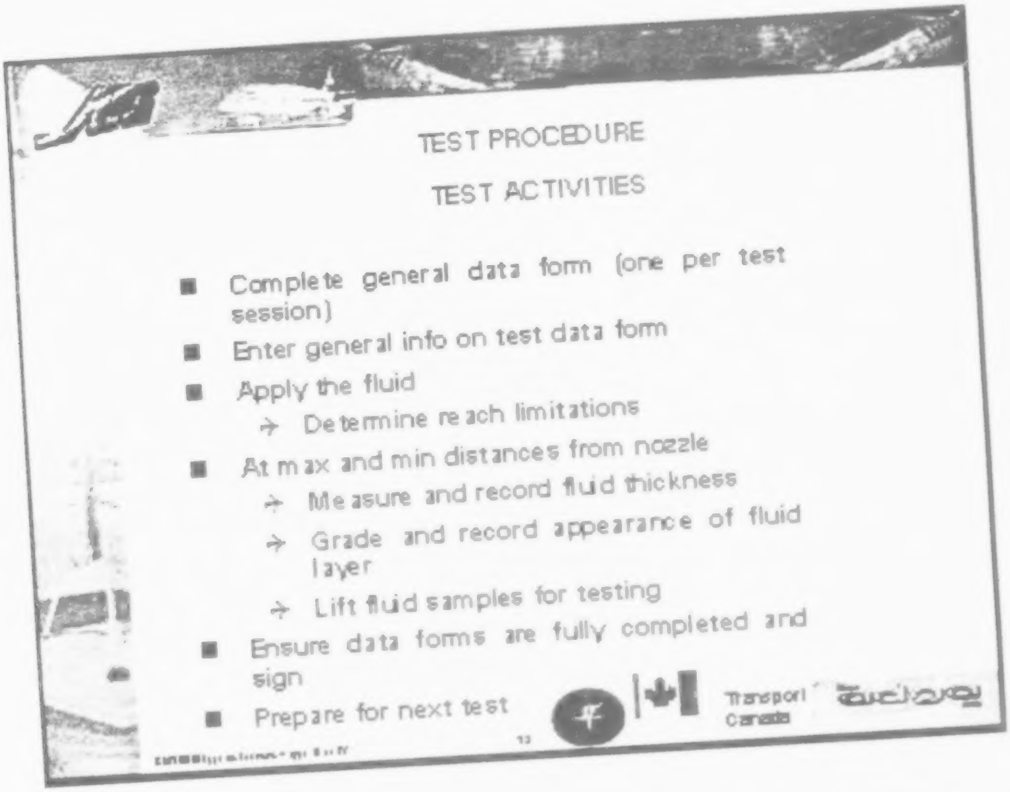


TEST PROCEDURE

TEST ACTIVITIES

- Complete general data form (one per test session)
- Enter general info on test data form
- Apply the fluid
  - → Determine reach limitations
- At max and min distances from nozzle
  - → Measure and record fluid thickness
  - → Grade and record appearance of fluid layer
  - → Lift fluid samples for testing
- Ensure data forms are fully completed and sign
- Prepare for next test

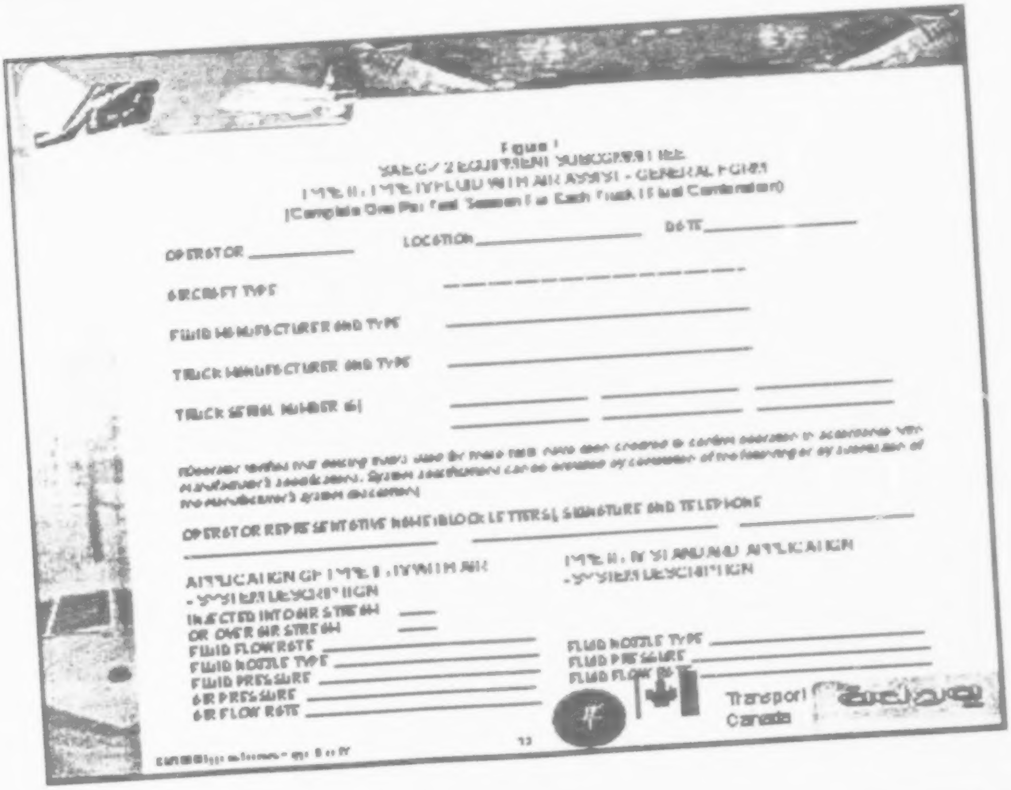


Figure 1
SAE G-12 EQUIPMENT SUBCOMMITTEE
TYPE II, TYPE IV FLUID WITH AIR ASSIST - GENERAL FORM
(Complete One Per Test Session For Each Truck / Fluid Combination)

OPERATOR ________ LOCATION ________ DATE ________

AIRCRAFT TYPE ________

FLUID MANUFACTURER AND TYPE ________

TRUCK MANUFACTURER AND TYPE ________

TRUCK SERIAL NUMBER (S) ________ ________ ________

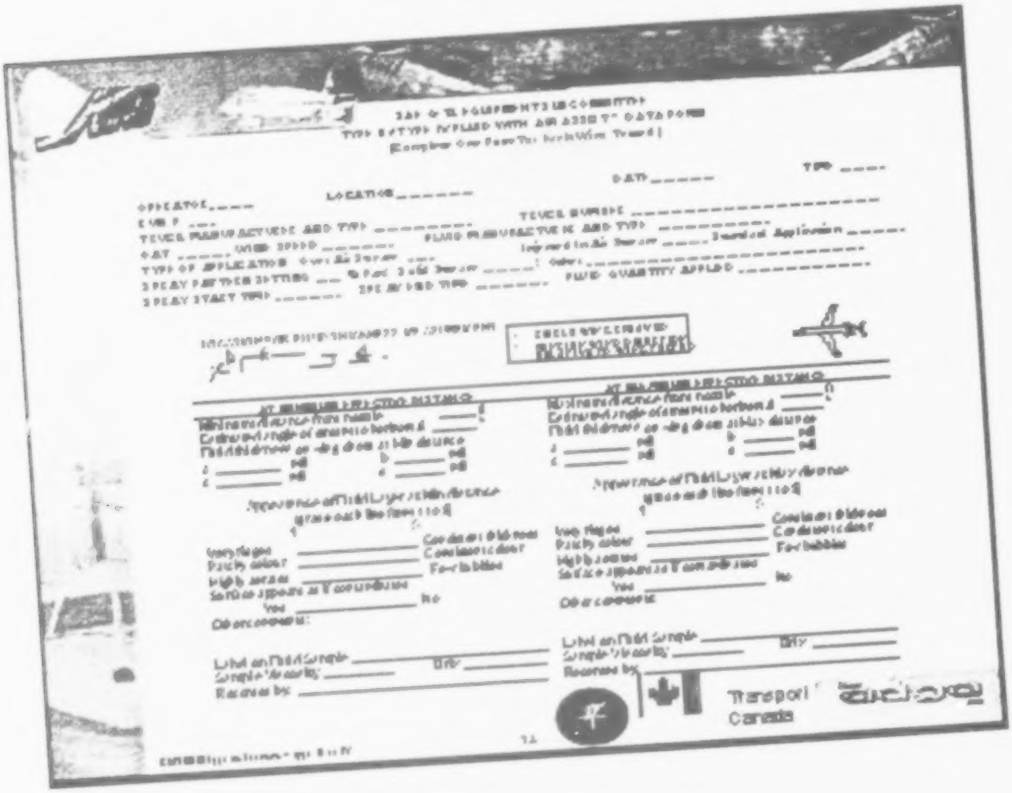
[illegible]

OPERATOR REPRESENTATIVE NAME (BLOCK LETTERS), SIGNATURE AND TELEPHONE

________ ________ ________

APPLICATION OF TYPE II, IV WITH AIR
- SYSTEM DESCRIPTION
INJECTED INTO AIR STREAM ____
OR OVER AIR STREAM ____
FLUID FLOW RATE ________
FLUID NOZZLE TYPE ________
FLUID PRESSURE ________
AIR PRESSURE ________
AIR FLOW RATE ________

TYPE II, IV STANDARD APPLICATION
- SYSTEM DESCRIPTION
FLUID NOZZLE TYPE ________
FLUID PRESSURE ________
FLUID FLOW RATE ________



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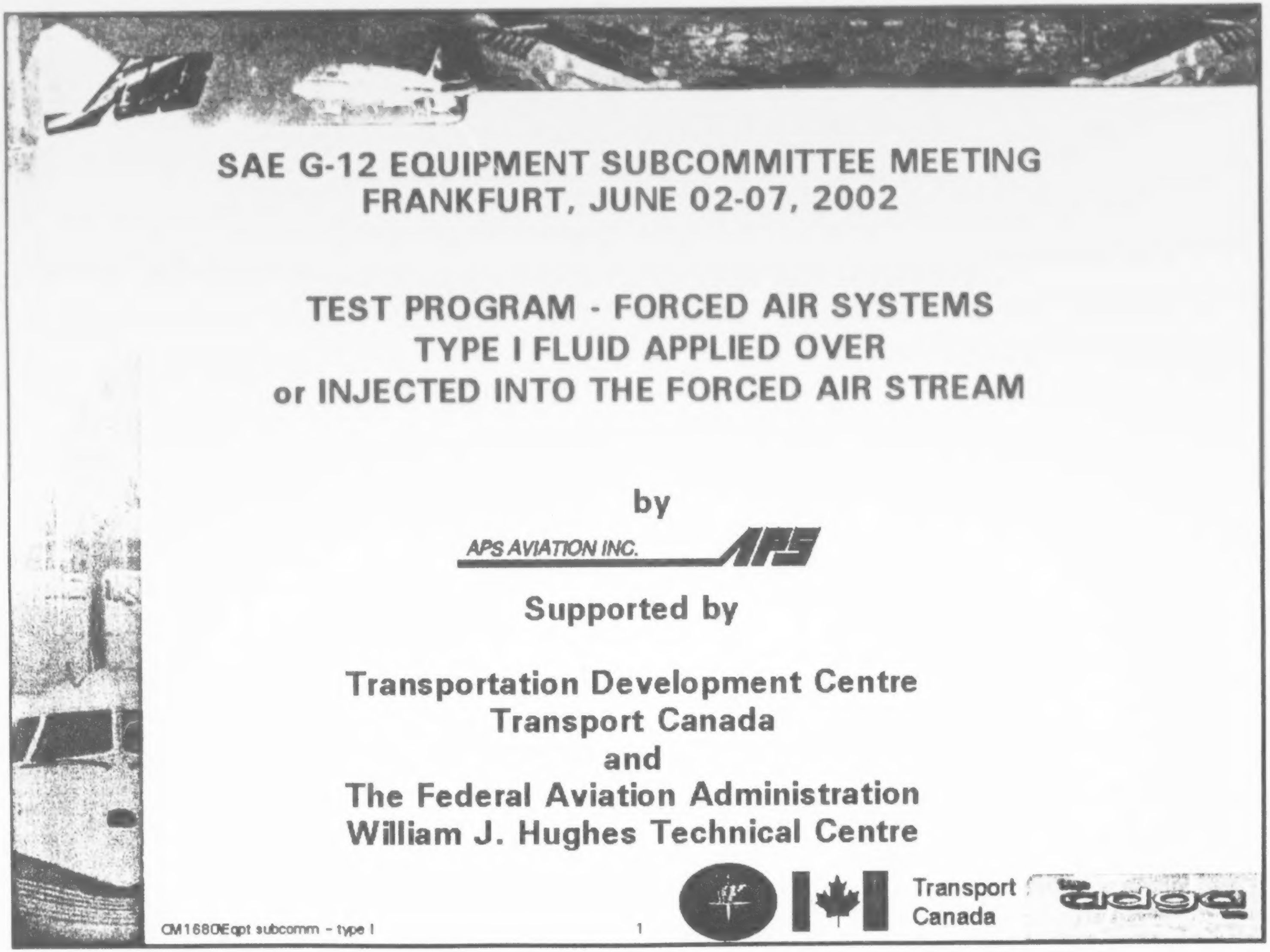

SAE G-12 EQUIPMENT SUBCOMMITTEE MEETING
FRANKFURT, JUNE 02-07, 2002

TEST PROGRAM - FORCED AIR SYSTEMS
TYPE I FLUID APPLIED OVER
or INJECTED INTO THE FORCED AIR STREAM

by

APS AVIATION INC.

Supported by

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
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CM1680Eqpt subcomm - type I

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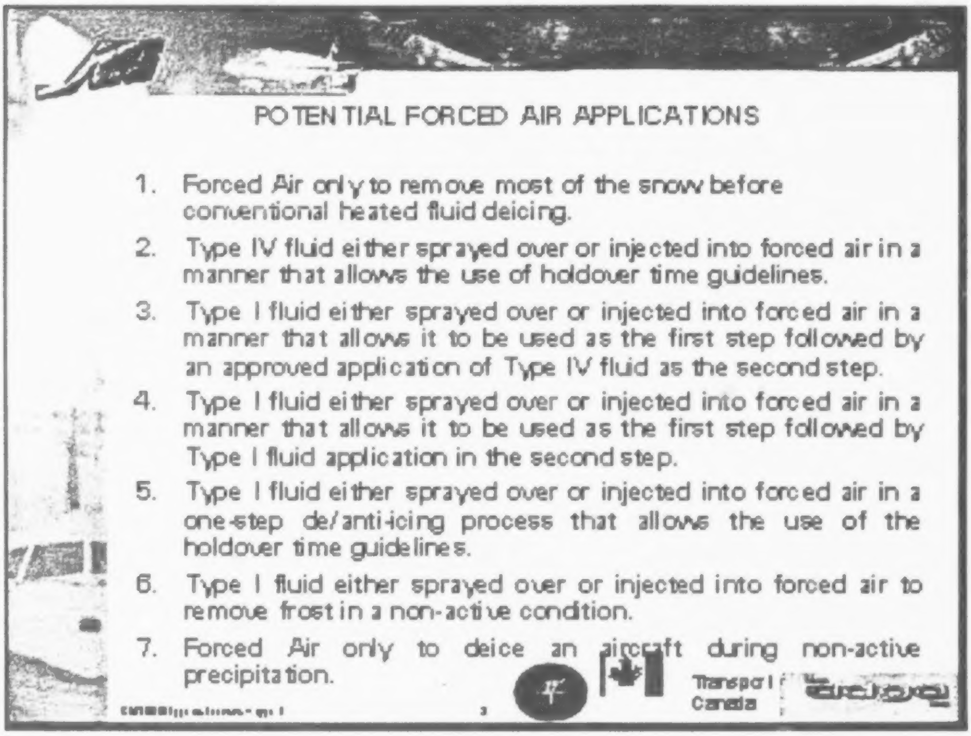

POTENTIAL FORCED AIR APPLICATIONS

1. Forced Air only to remove most of the snow before conventional heated fluid deicing.
2. Type IV fluid either sprayed over or injected into forced air in a manner that allows the use of holdover time guidelines.
3. Type I fluid either sprayed over or injected into forced air in a manner that allows it to be used as the first step followed by an approved application of Type IV fluid as the second step.
4. Type I fluid either sprayed over or injected into forced air in a manner that allows it to be used as the first step followed by Type I fluid application in the second step.
5. Type I fluid either sprayed over or injected into forced air in a one-step de/anti-icing process that allows the use of the holdover time guidelines.
6. Type I fluid either sprayed over or injected into forced air to remove frost in a non-active condition.
7. Forced Air only to deice an aircraft during non-active precipitation.

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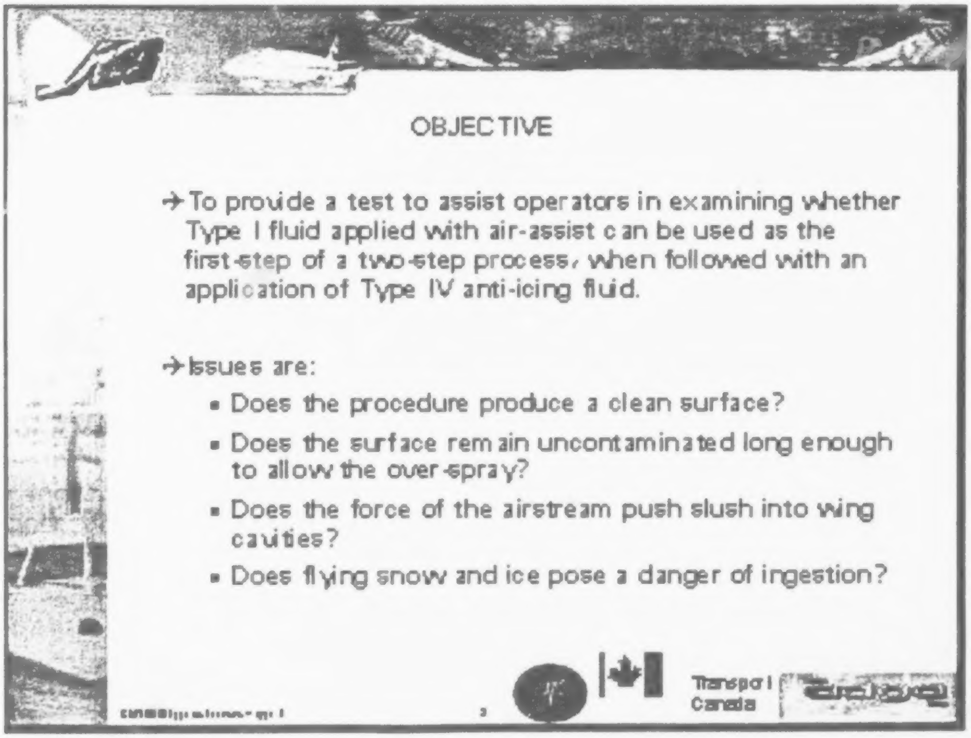

OBJECTIVE

→ To provide a test to assist operators in examining whether Type I fluid applied with air-assist can be used as the first-step of a two-step process, when followed with an application of Type IV anti-icing fluid.

→ Issues are:
- Does the procedure produce a clean surface?
- Does the surface remain uncontaminated long enough to allow the over-spray?
- Does the force of the airstream push slush into wing cavities?
- Does flying snow and ice pose a danger of ingestion?

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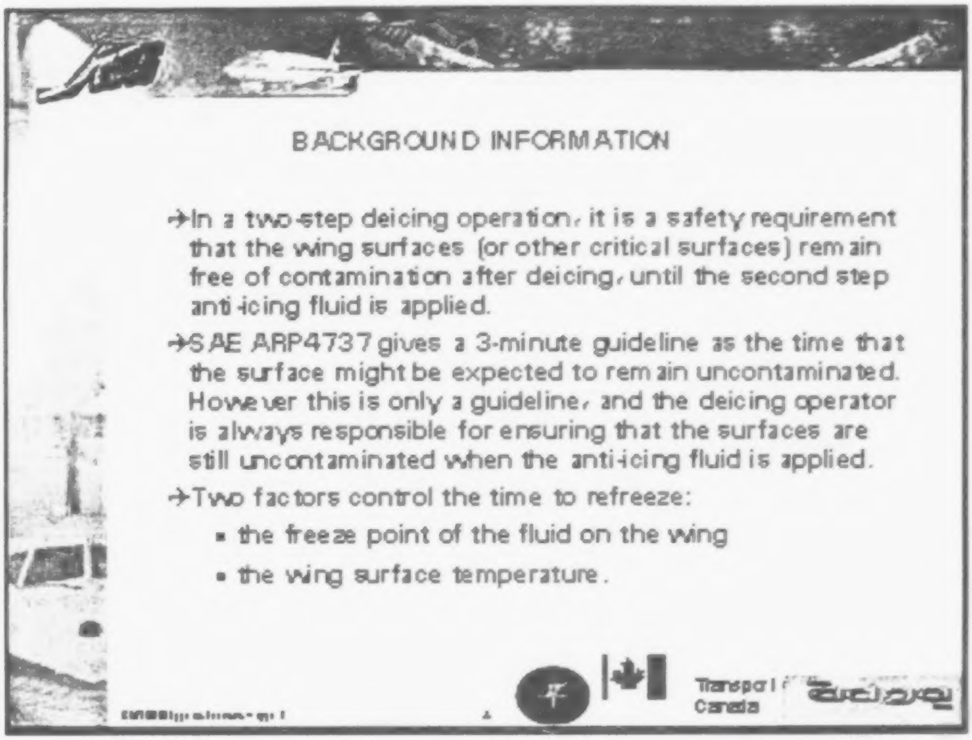

BACKGROUND INFORMATION

→In a two-step deicing operation, it is a safety requirement that the wing surfaces (or other critical surfaces) remain free of contamination after deicing, until the second step anti-icing fluid is applied.

→SAE ARP4737 gives a 3-minute guideline as the time that the surface might be expected to remain uncontaminated. However this is only a guideline, and the deicing operator is always responsible for ensuring that the surfaces are still uncontaminated when the anti-icing fluid is applied.

→Two factors control the time to refreeze:

- the freeze point of the fluid on the wing
- the wing surface temperature.

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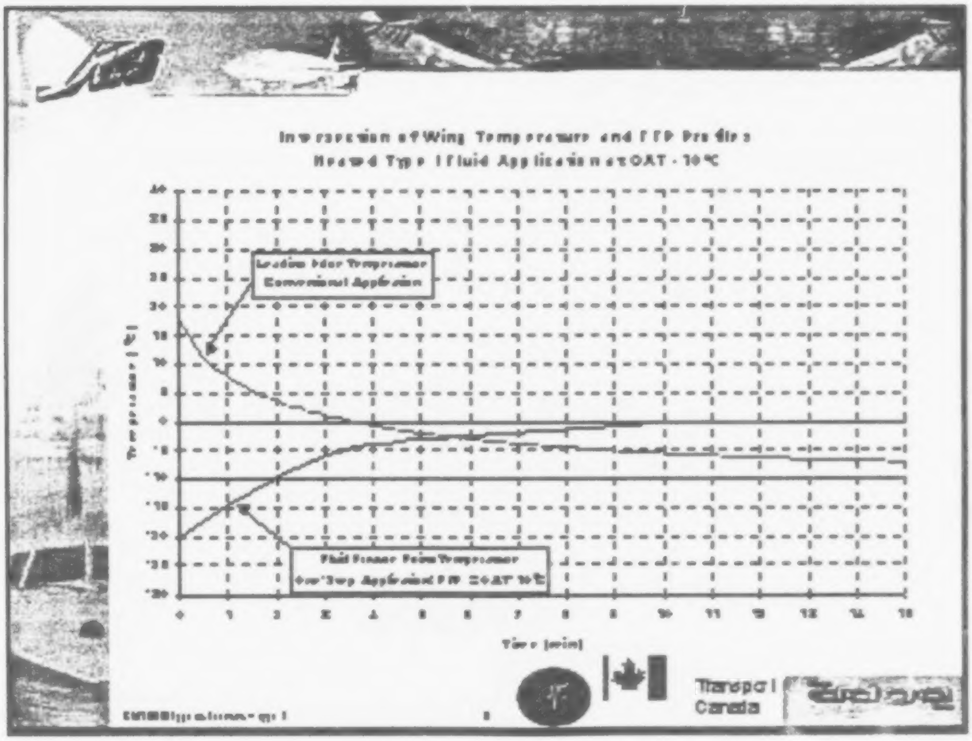

Interaction of Wing Temperature and FFP Profiles
Heated Type I Fluid Application at OAT -10°C

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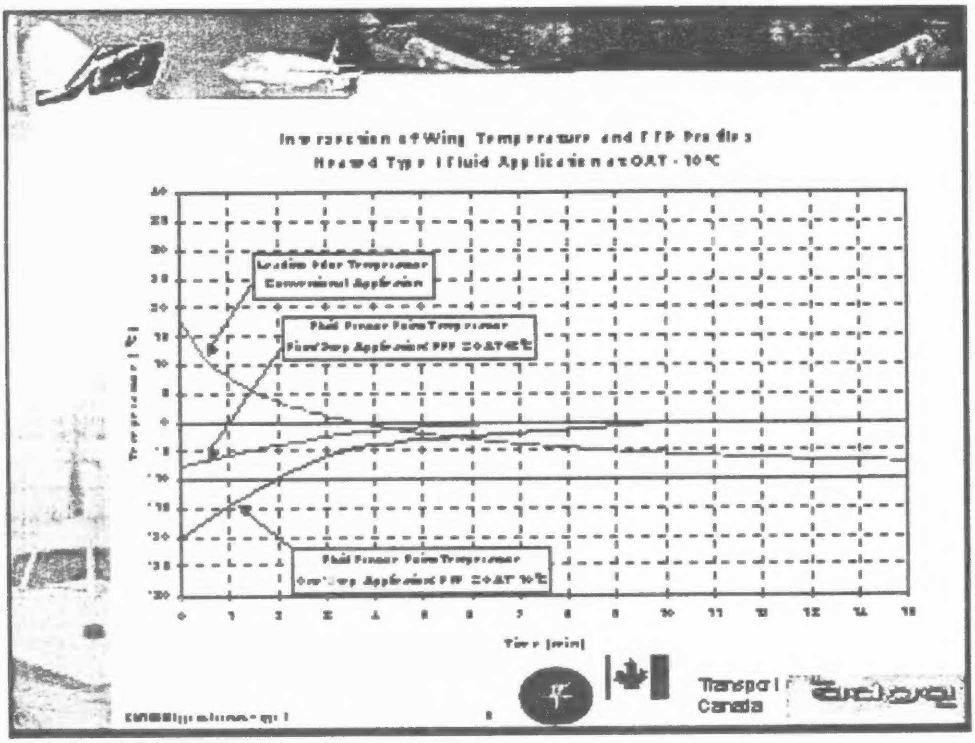
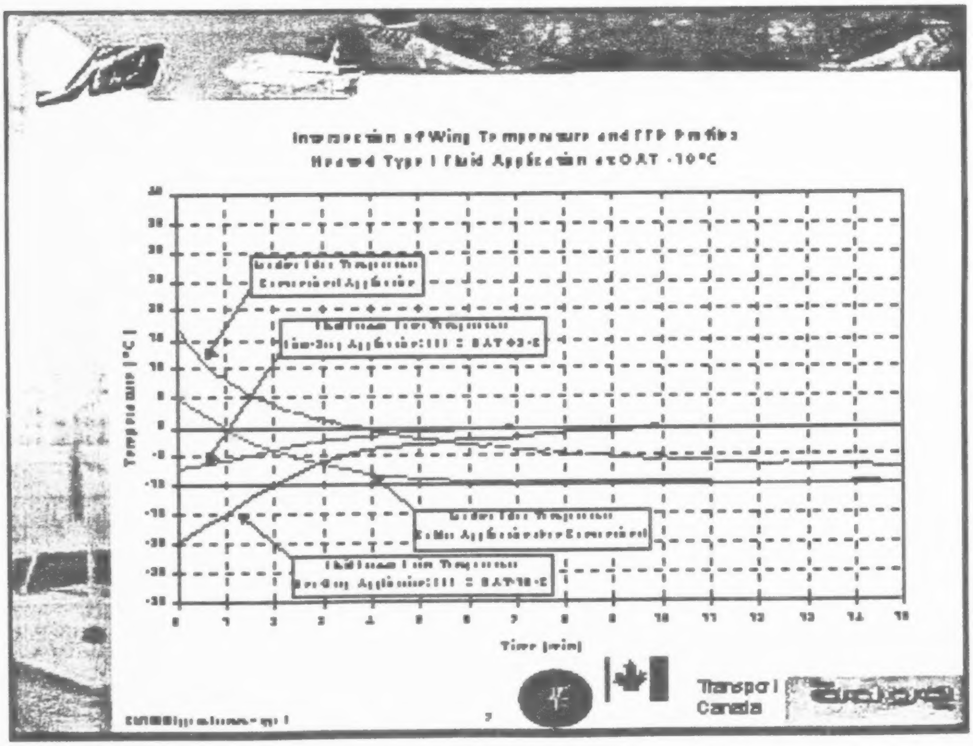
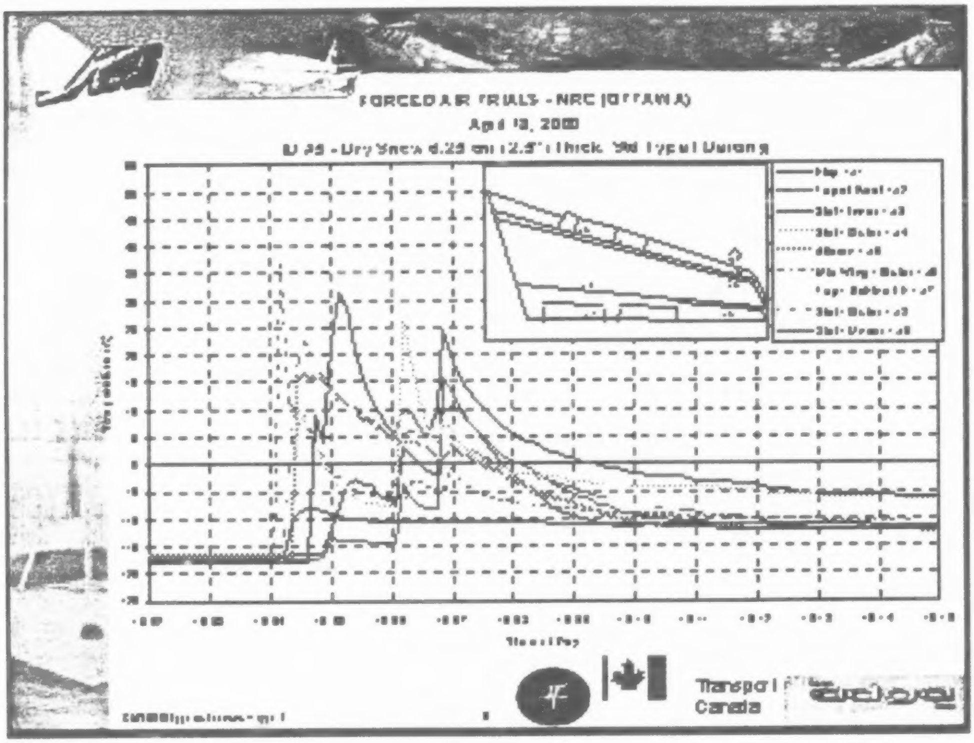


Intersection of Wing Temperature and FFP Profiles
Heated Type I Fluid Application at OAT -10°C



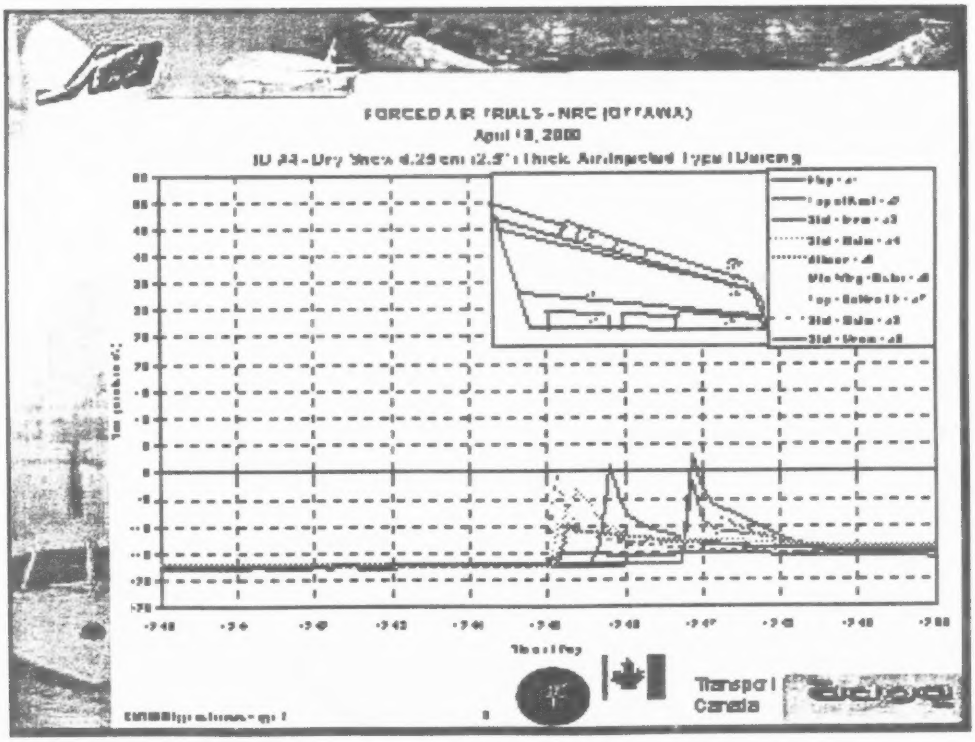
Intersection of Wing Temperature and FFP Profiles
Heated Type I Fluid Application at OAT -10°C



FORCED AIR TRIALS - NRC (OTTAWA)

April 13, 2000

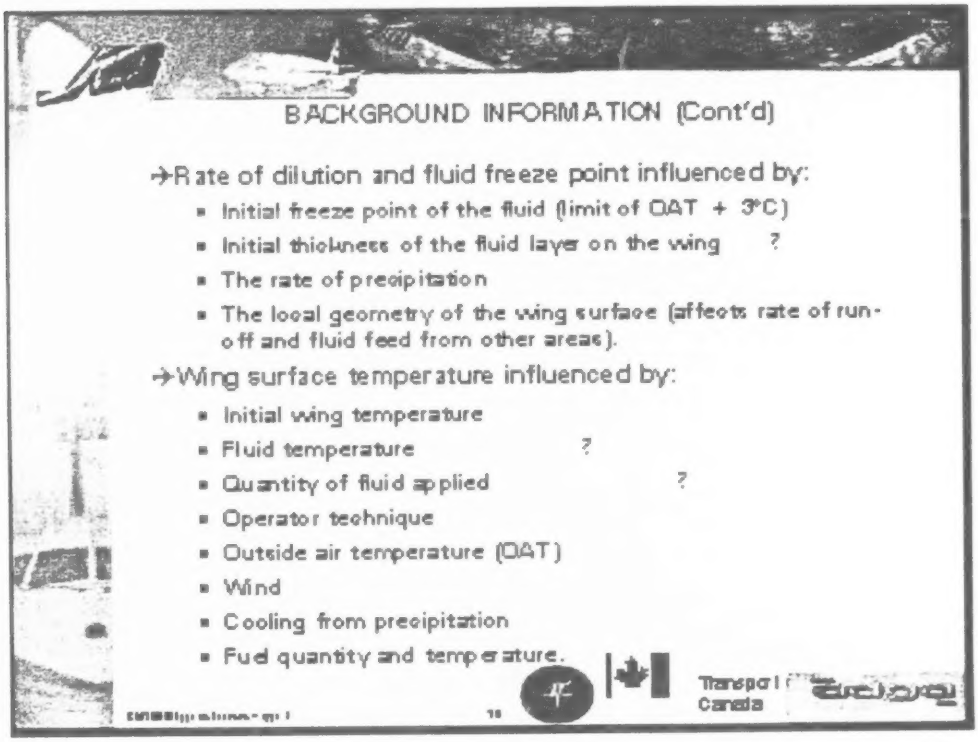
ID 25 - Dry Snow 6.25 cm (2.5") Thick, Std Type I Deicing



FORCED AIR TRIALS - NRC (OTTAWA)

April 13, 2000

ID 24 - Dry Snow 6.25 cm (2.5") Thick, Air-Injected Type I Deicing



BACKGROUND INFORMATION (Cont'd)

→Rate of dilution and fluid freeze point influenced by:
- Initial freeze point of the fluid (limit of OAT + 3°C)
- Initial thickness of the fluid layer on the wing ?
- The rate of precipitation
- The local geometry of the wing surface (affects rate of run-off and fluid feed from other areas).

→Wing surface temperature influenced by:
- Initial wing temperature
- Fluid temperature ?
- Quantity of fluid applied ?
- Operator technique
- Outside air temperature (OAT)
- Wind
- Cooling from precipitation
- Fuel quantity and temperature.

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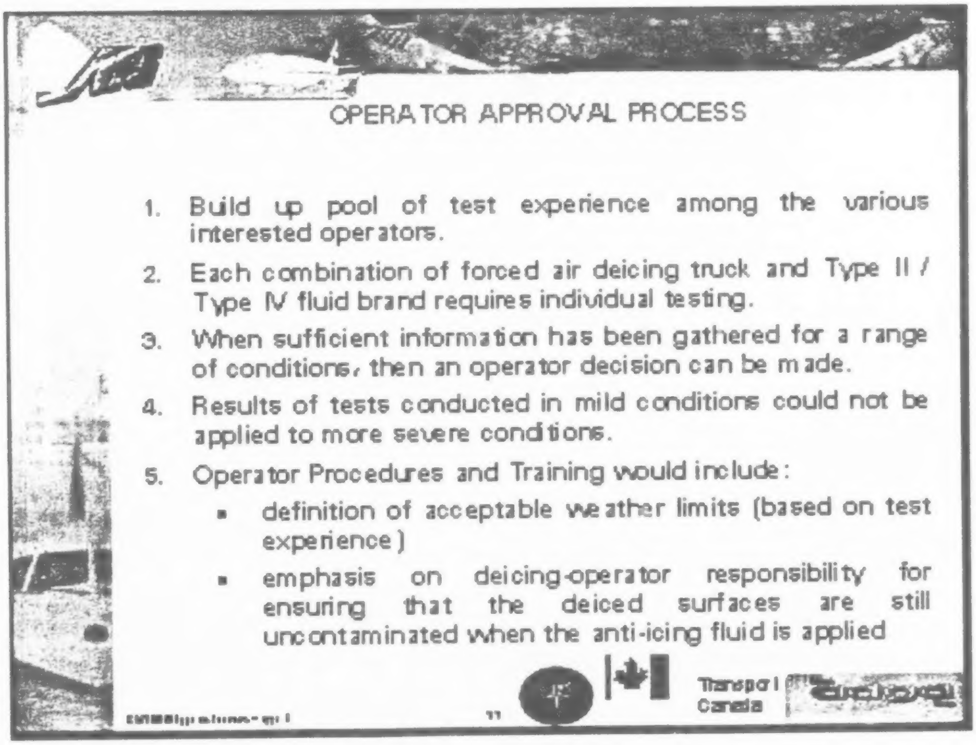

OPERATOR APPROVAL PROCESS

1. Build up pool of test experience among the various interested operators.
2. Each combination of forced air deicing truck and Type II / Type IV fluid brand requires individual testing.
3. When sufficient information has been gathered for a range of conditions, then an operator decision can be made.
4. Results of tests conducted in mild conditions could not be applied to more severe conditions.
5. Operator Procedures and Training would include:
   - definition of acceptable weather limits (based on test experience)
   - emphasis on deicing-operator responsibility for ensuring that the deiced surfaces are still uncontaminated when the anti-icing fluid is applied

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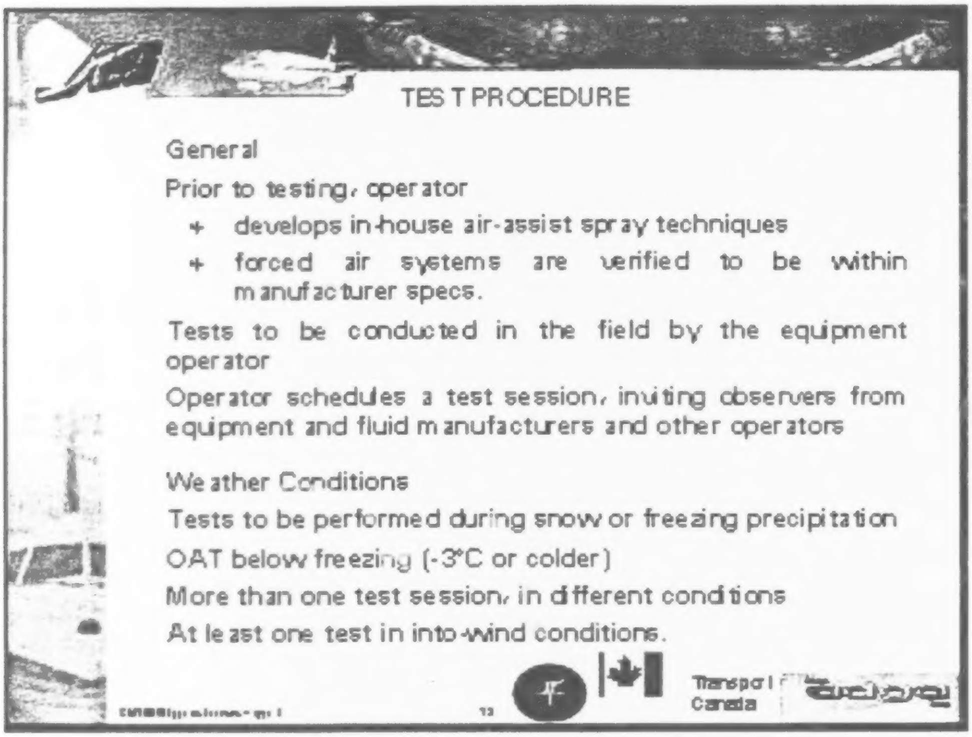

TEST PROCEDURE

General

Prior to testing, operator

- develops in-house air-assist spray techniques
- forced air systems are verified to be within manufacturer specs.

Tests to be conducted in the field by the equipment operator

Operator schedules a test session, inviting observers from equipment and fluid manufacturers and other operators

Weather Conditions

Tests to be performed during snow or freezing precipitation

OAT below freezing (-3°C or colder)

More than one test session, in different conditions

At least one test in into-wind conditions.

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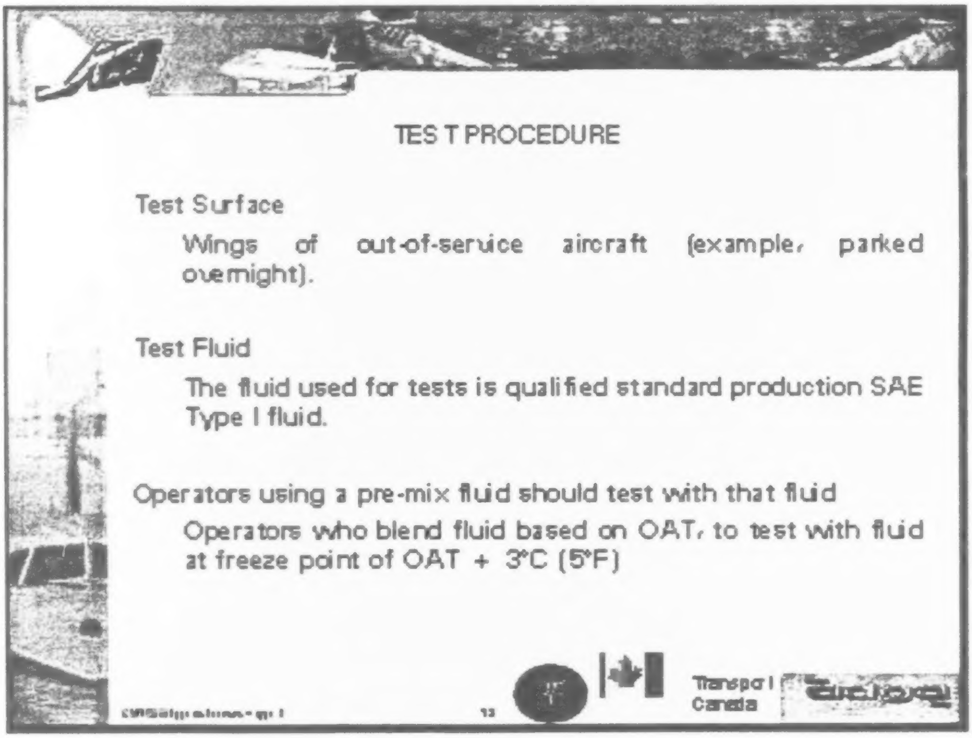

TEST PROCEDURE

Test Surface

Wings of out-of-service aircraft (example, parked overnight).

Test Fluid

The fluid used for tests is qualified standard production SAE Type I fluid.

Operators using a pre-mix fluid should test with that fluid

Operators who blend fluid based on OAT, to test with fluid at freeze point of OAT + 3°C (5°F)

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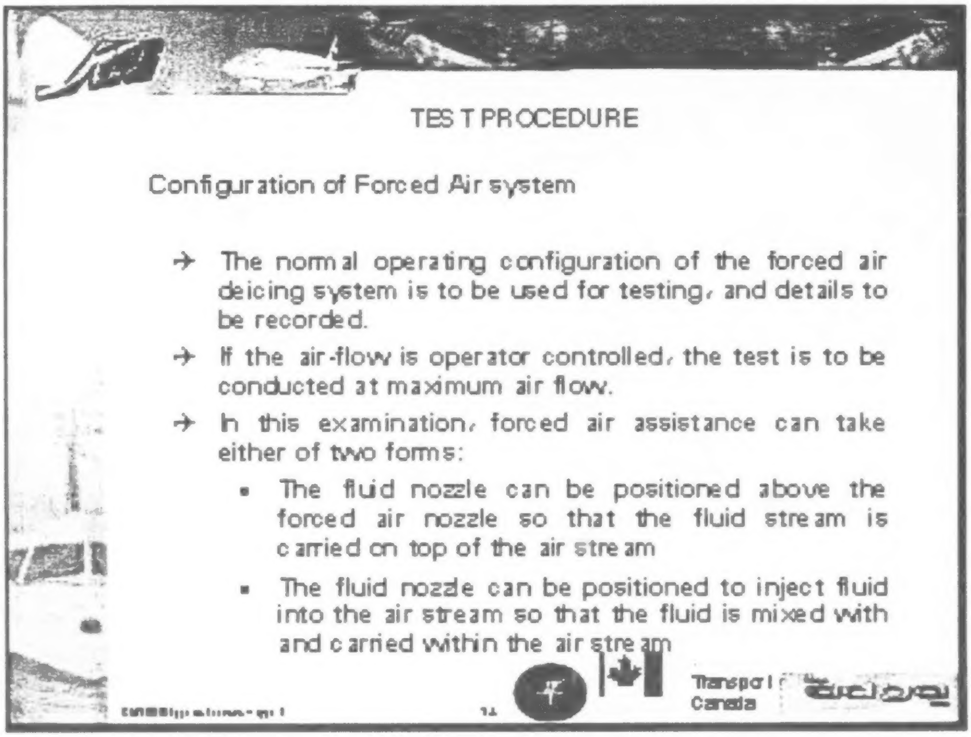

TEST PROCEDURE

Configuration of Forced Air system

- → The normal operating configuration of the forced air deicing system is to be used for testing, and details to be recorded.
- → If the air-flow is operator controlled, the test is to be conducted at maximum air flow.
- → In this examination, forced air assistance can take either of two forms:
  - The fluid nozzle can be positioned above the forced air nozzle so that the fluid stream is carried on top of the air stream
  - The fluid nozzle can be positioned to inject fluid into the air stream so that the fluid is mixed with and carried within the air stream

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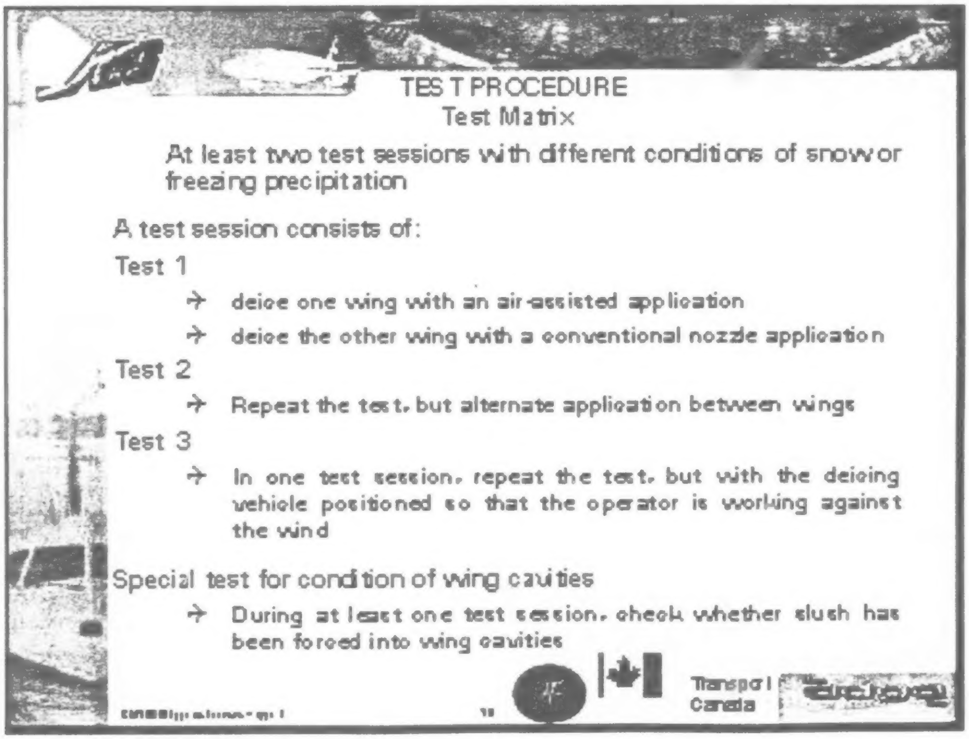

TEST PROCEDURE
Test Matrix

At least two test sessions with different conditions of snow or freezing precipitation

A test session consists of:

Test 1

- → deice one wing with an air-assisted application
- → deice the other wing with a conventional nozzle application

Test 2

- → Repeat the test, but alternate application between wings

Test 3

- → In one test session, repeat the test, but with the deicing vehicle positioned so that the operator is working against the wind

Special test for condition of wing cavities

- → During at least one test session, check whether slush has been forced into wing cavities

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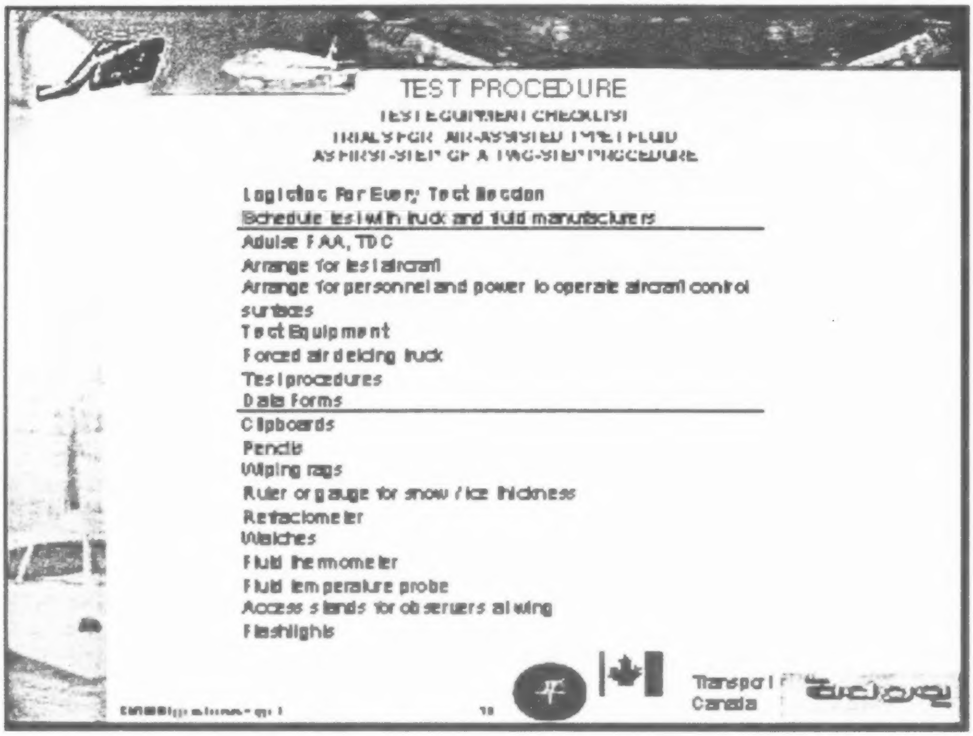

TEST PROCEDURE

TEST EQUIPMENT CHECKLIST
TRIALS FOR AIR-ASSISTED TYPE I FLUID
AS FIRST-STEP OF A TWO-STEP PROCEDURE

Logistics For Every Test Session

Schedule tests with truck and fluid manufacturers

Advise FAA, TDC
Arrange for test aircraft
Arrange for personnel and power to operate aircraft control surfaces
Test Equipment
Forced air deicing truck
Test procedures
Data Forms

Clipboards
Pencils
Wiping rags
Ruler or gauge for snow / ice thickness
Refractometer
Watches
Fluid thermometer
Fluid temperature probe
Access stands for observers at wing
Flashlights

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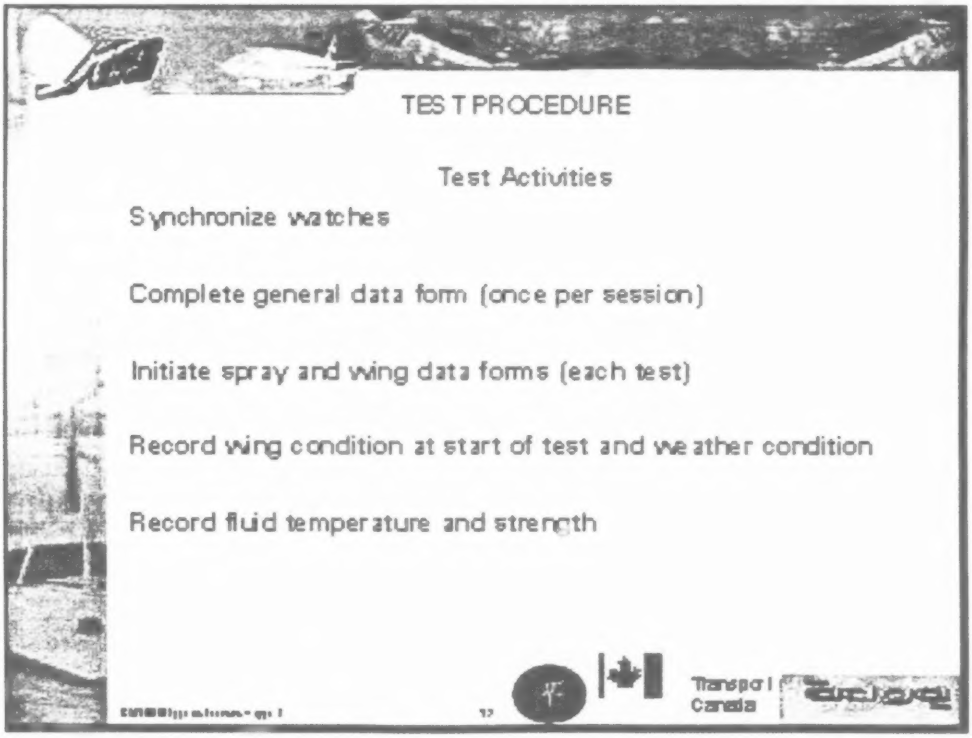

TEST PROCEDURE

Test Activities

Synchronize watches

Complete general data form (once per session)

Initiate spray and wing data forms (each test)

Record wing condition at start of test and weather condition

Record fluid temperature and strength

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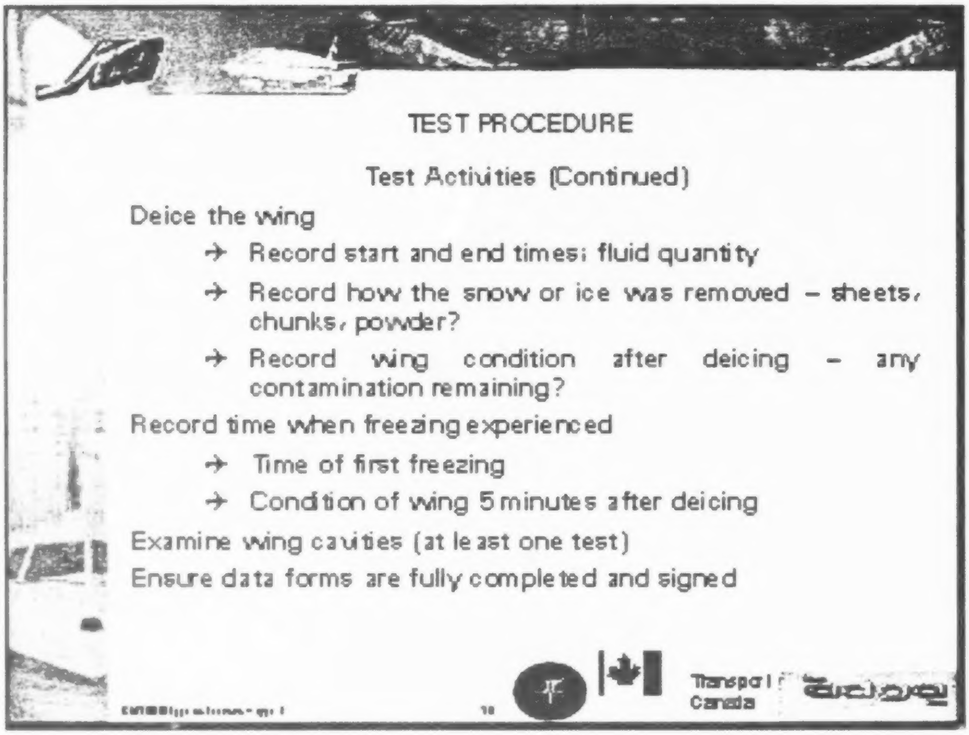

TEST PROCEDURE

Test Activities (Continued)

Deice the wing

- → Record start and end times; fluid quantity
- → Record how the snow or ice was removed – sheets, chunks, powder?
- → Record wing condition after deicing – any contamination remaining?

Record time when freezing experienced

- → Time of first freezing
- → Condition of wing 5 minutes after deicing

Examine wing cavities (at least one test)

Ensure data forms are fully completed and signed

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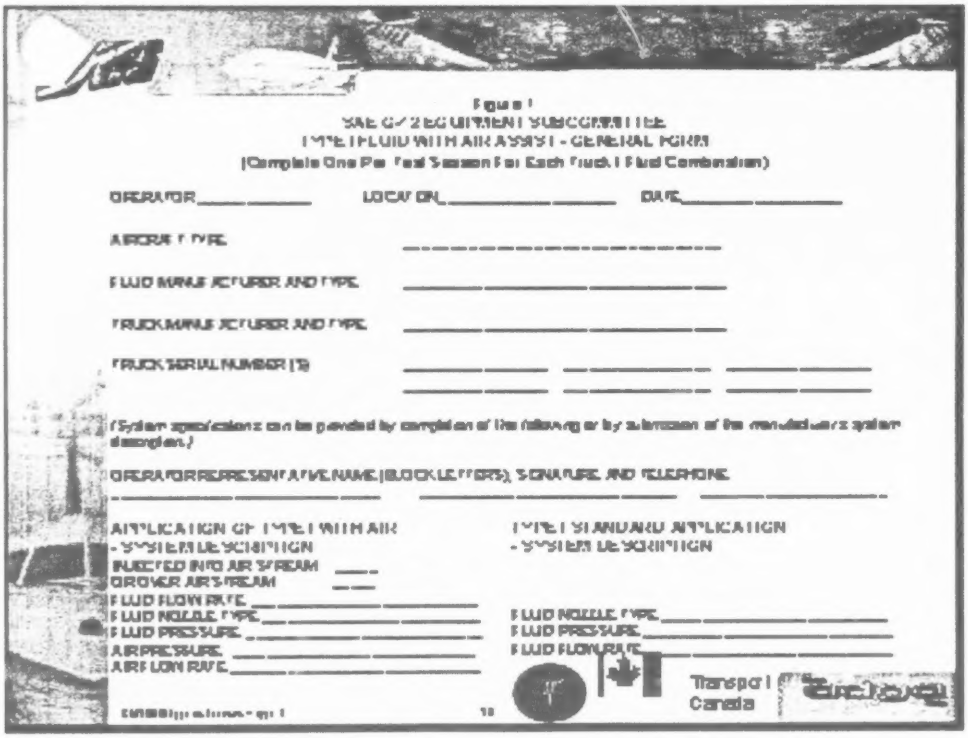

Figure 1
SAE G-12 EQUIPMENT SUBCOMMITTEE
TYPE I FLUID WITH AIR ASSIST - GENERAL FORM
(Complete One Per Test Season For Each Truck / Fluid Combination)

OPERATOR ____________ LOCATION ________________ DATE ________________

AIRCRAFT TYPE ________________________

FLUID MANUFACTURER AND TYPE ________________________

TRUCK MANUFACTURER AND TYPE ________________________

TRUCK SERIAL NUMBER (S) ____________ ____________ ____________
____________ ____________ ____________

(System specifications can be provided by completion of the following or by submission of the manufacturer's system description.)

OPERATOR REPRESENTATIVE NAME (BLOCK LETTERS), SIGNATURE AND TELEPHONE
____________________ ____________________ ____________________

APPLICATION OF TYPE I WITH AIR
- SYSTEM DESCRIPTION
INJECTED INTO AIR STREAM ___
OR OVER AIR STREAM ___
FLUID FLOW RATE ________________
FLUID NOZZLE TYPE ________________
FLUID PRESSURE ________________
AIR PRESSURE ________________
AIR FLOW RATE ________________

TYPE I STANDARD APPLICATION
- SYSTEM DESCRIPTION
FLUID NOZZLE TYPE ________________
FLUID PRESSURE ________________
FLUID FLOW RATE ________________

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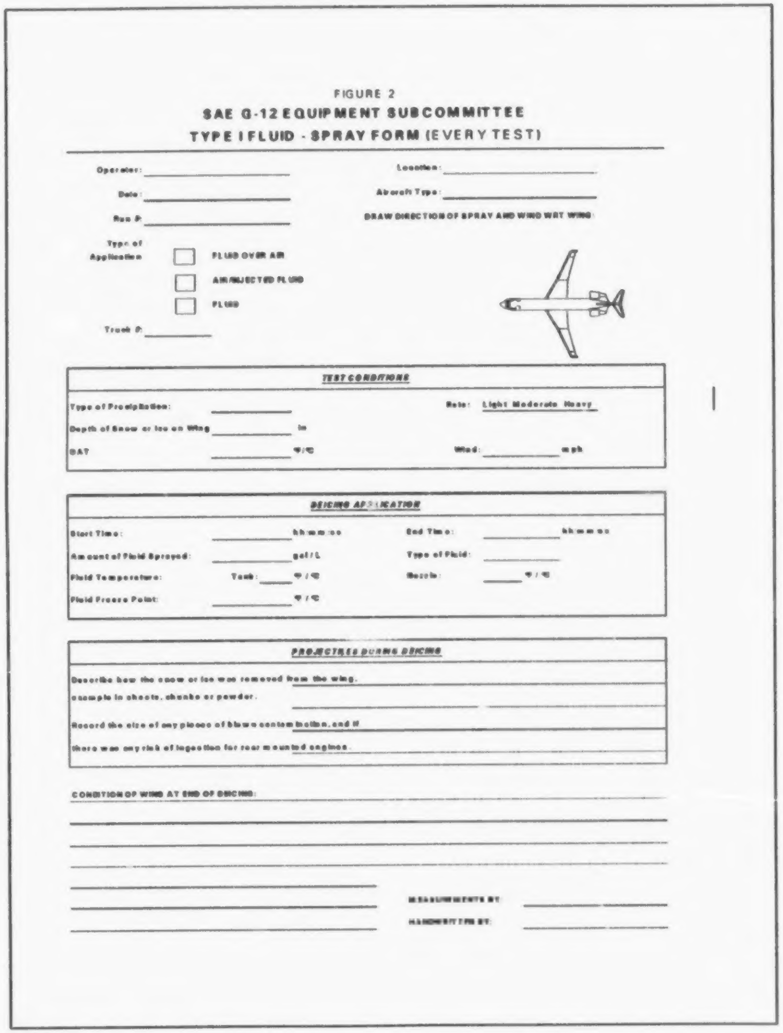


FIGURE 2

SAE G-12 EQUIPMENT SUBCOMMITTEE

TYPE I FLUID - SPRAY FORM (EVERY TEST)

Operator: ____

Date: ____

Run #: ____

Location: ____

Aircraft Type: ____

DRAW DIRECTION OF SPRAY AND WIND WRT WING:

Type of Application:

☐ FLUID OVER AIR

☐ AIR/INJECTED FLUID

☐ FLUID

Truck #: ____

TEST CONDITIONS

Type of Precipitation: ____

Rate: Light Moderate Heavy

Depth of Snow or Ice on Wing ____ in

OAT ____ °F/°C

Wind: ____ mph

DEICING APPLICATION

Start Time: ____ hh:mm:ss

End Time: ____ hh:mm:ss

Amount of Fluid Sprayed: ____ gal/L

Type of Fluid: ____

Fluid Temperature: Tank: ____ °F/°C

Nozzle: ____ °F/°C

Fluid Freeze Point: ____ °F/°C

PROJECTILES DURING DEICING

Describe how the snow or ice was removed from the wing, example in sheets, chunks or powder. ____

Record the size of any pieces of blown contamination, and if there was any risk of ingestion for rear mounted engines. ____

CONDITION OF WING AT END OF DEICING: ____

MEASUREMENTS BY: ____

HANDWRITTEN BY: ____

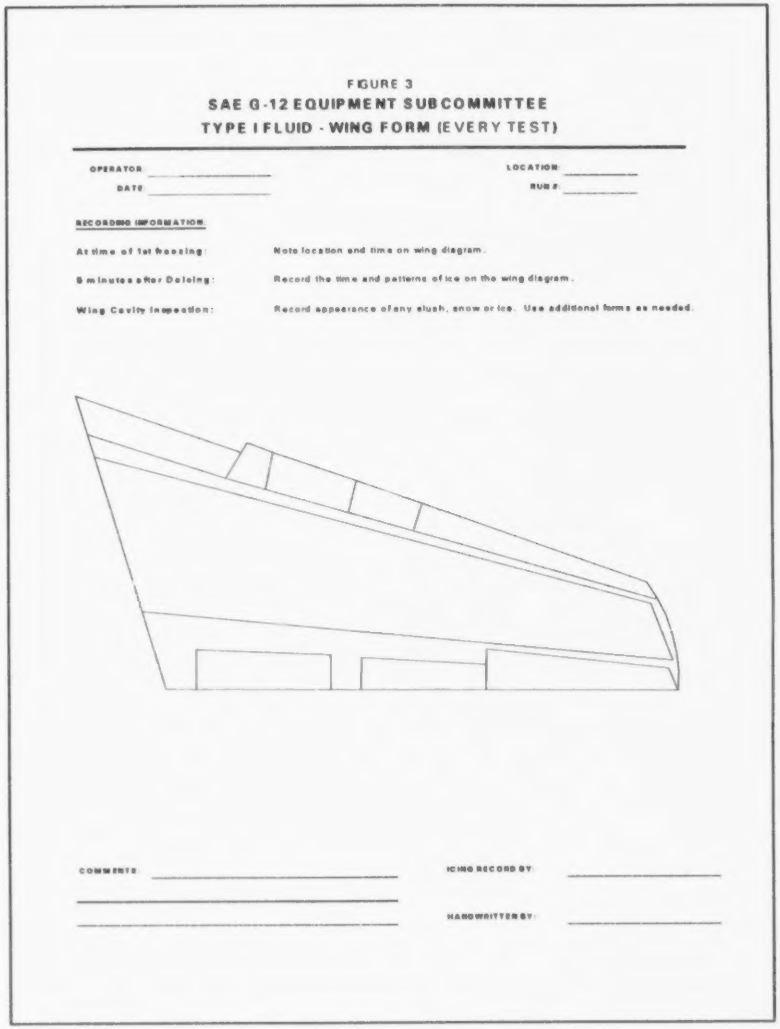


FIGURE 3

SAE G-12 EQUIPMENT SUBCOMMITTEE

TYPE I FLUID - WING FORM (EVERY TEST)

OPERATOR ____

DATE ____

LOCATION: ____

RUN #: ____

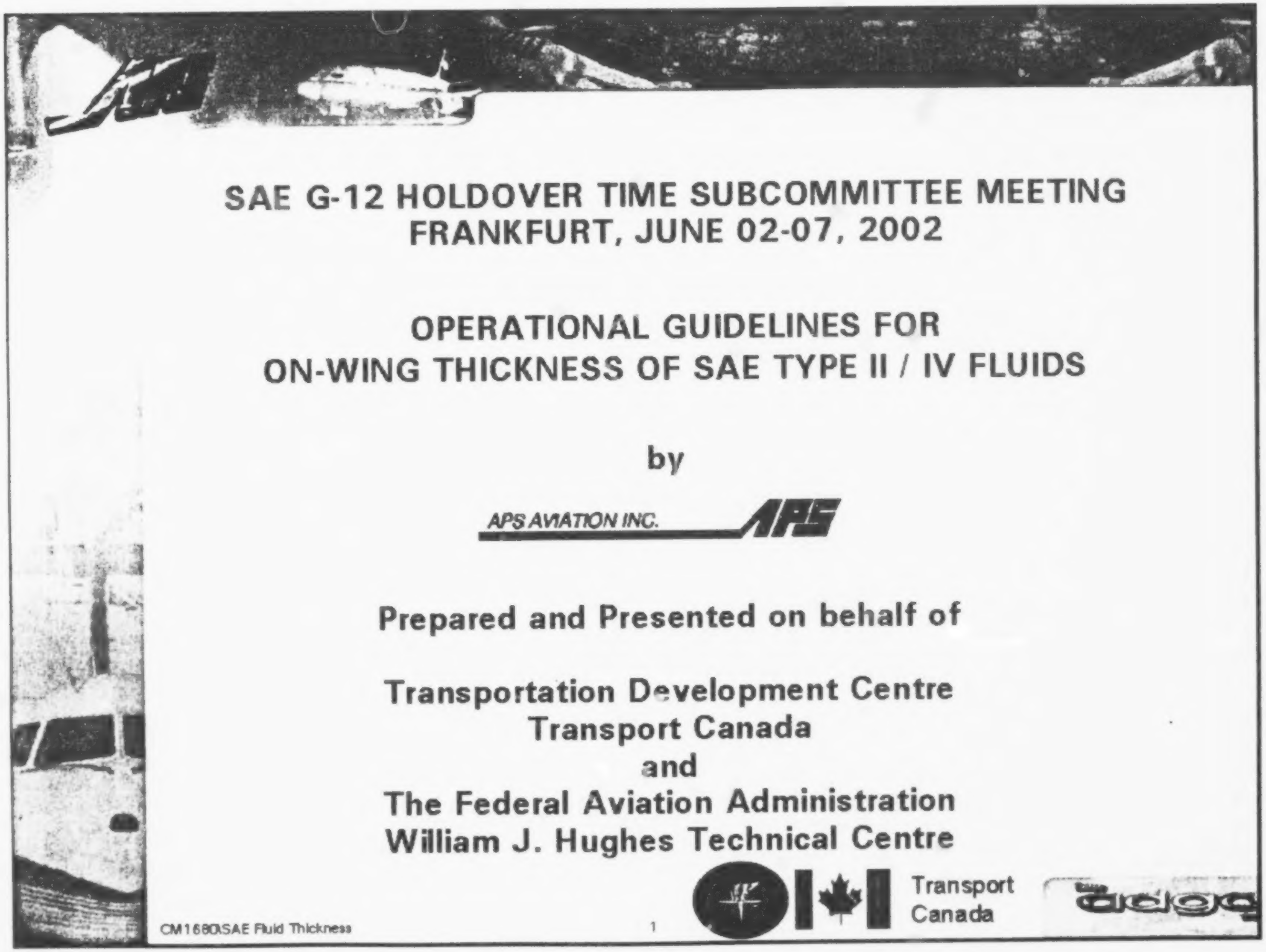
RECORDING INFORMATION:

At time of 1st freezing:	Note location and time on wing diagram.
5 minutes after Deicing:	Record the time and patterns of ice on the wing diagram.
Wing Cavity Inspection:	Record appearance of any slush, snow or ice. Use additional forms as needed.

COMMENTS: ____

ICING RECORD BY: ____

HANDWRITTEN BY: ____



SAE G-12 HOLDOVER TIME SUBCOMMITTEE MEETING
FRANKFURT, JUNE 02-07, 2002

OPERATIONAL GUIDELINES FOR ON-WING THICKNESS OF SAE TYPE II / IV FLUIDS

by

APS AVIATION INC.

Prepared and Presented on behalf of

Transportation Development Centre
Transport Canada
and
The Federal Aviation Administration
William J. Hughes Technical Centre

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CM1680\SAE Fluid Thickness

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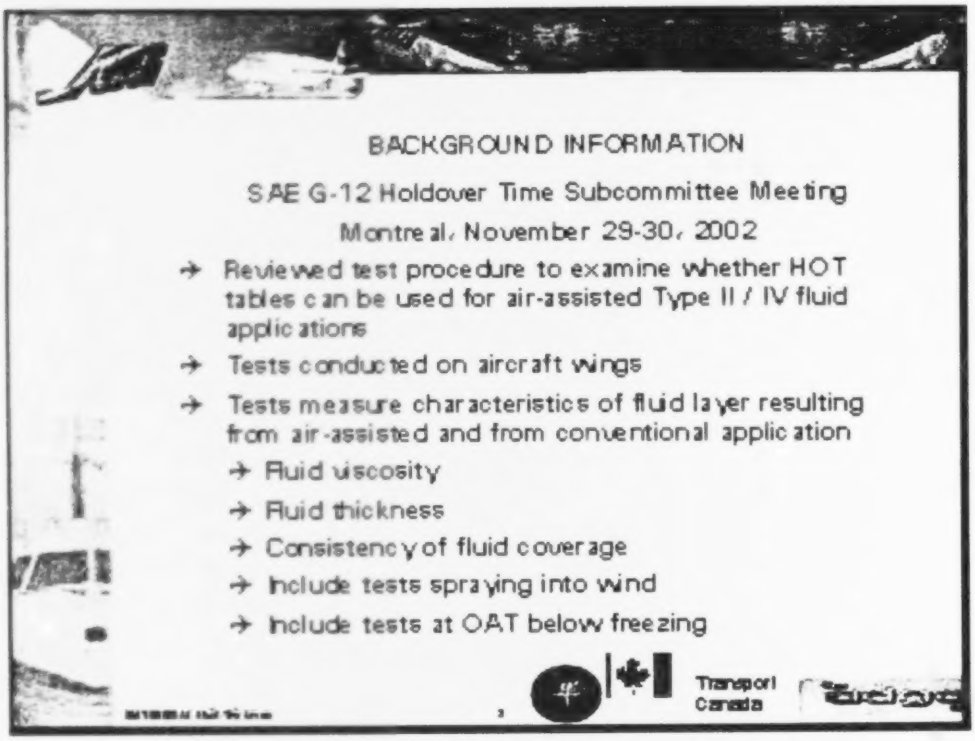

BACKGROUND INFORMATION

SAE G-12 Holdover Time Subcommittee Meeting

Montreal, November 29-30, 2002

- Reviewed test procedure to examine whether HOT tables can be used for air-assisted Type II / IV fluid applications
- Tests conducted on aircraft wings
- Tests measure characteristics of fluid layer resulting from air-assisted and from conventional application
  - Fluid viscosity
  - Fluid thickness
  - Consistency of fluid coverage
  - Include tests spraying into wind
  - Include tests at OAT below freezing

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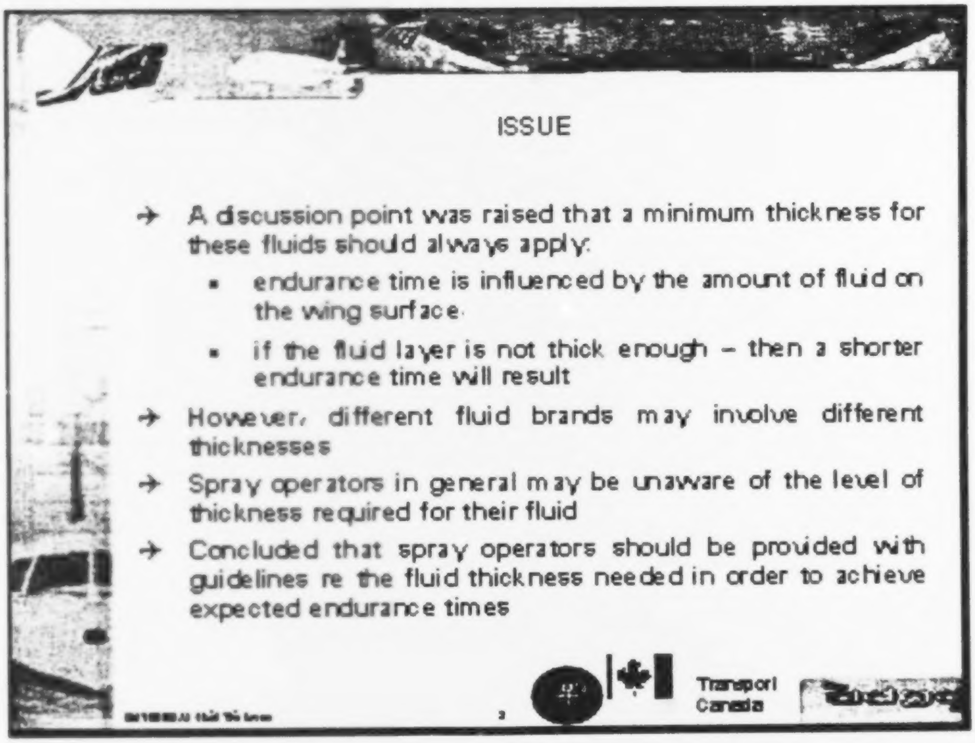

ISSUE

- A discussion point was raised that a minimum thickness for these fluids should always apply:
  - endurance time is influenced by the amount of fluid on the wing surface
  - if the fluid layer is not thick enough – then a shorter endurance time will result
- However, different fluid brands may involve different thicknesses
- Spray operators in general may be unaware of the level of thickness required for their fluid
- Concluded that spray operators should be provided with guidelines re the fluid thickness needed in order to achieve expected endurance times

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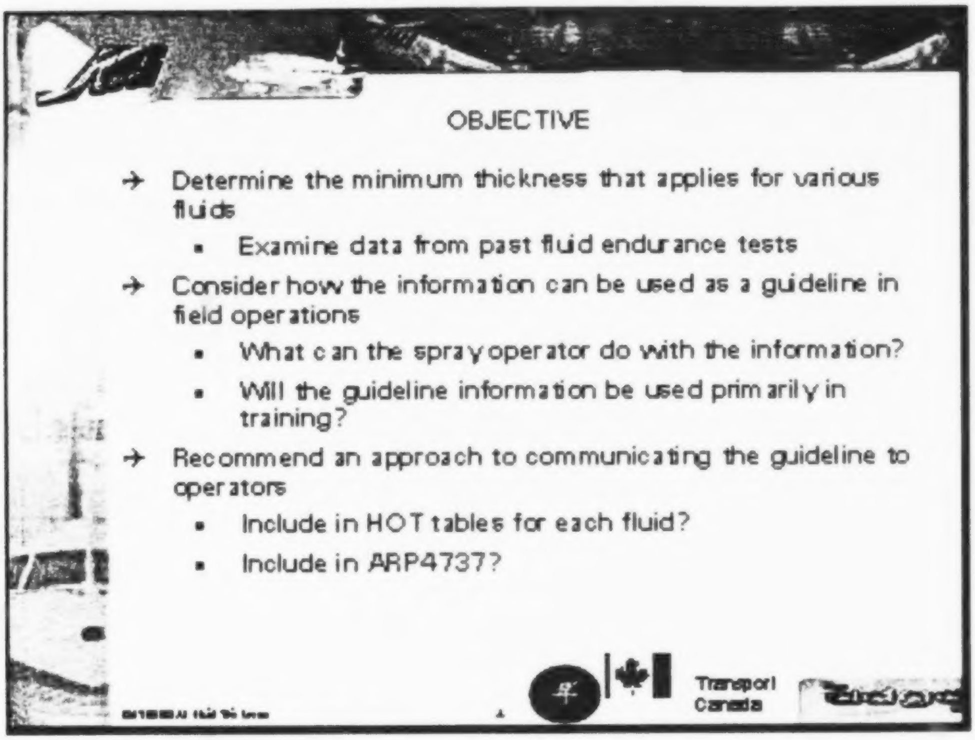

OBJECTIVE

- → Determine the minimum thickness that applies for various fluids
  - Examine data from past fluid endurance tests
- → Consider how the information can be used as a guideline in field operations
  - What can the spray operator do with the information?
  - Will the guideline information be used primarily in training?
- → Recommend an approach to communicating the guideline to operators
  - Include in HOT tables for each fluid?
  - Include in ARP4737?

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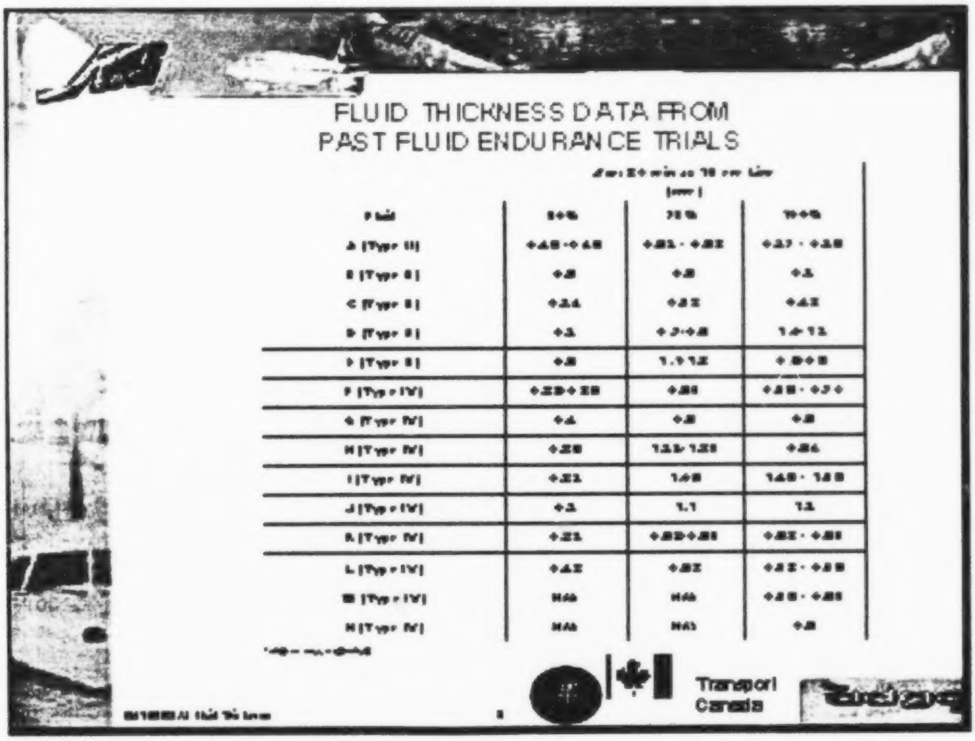

FLUID THICKNESS DATA FROM PAST FLUID ENDURANCE TRIALS

Fluid	50%	75%	100%
A (Type II)	[illegible]	[illegible]	[illegible]
B (Type II)	[illegible]	[illegible]	[illegible]
C (Type II)	[illegible]	[illegible]	[illegible]
D (Type II)	[illegible]	[illegible]	[illegible]
E (Type II)	[illegible]	[illegible]	[illegible]
F (Type IV)	[illegible]	[illegible]	[illegible]
G (Type IV)	[illegible]	[illegible]	[illegible]
H (Type IV)	[illegible]	[illegible]	[illegible]
I (Type IV)	[illegible]	[illegible]	[illegible]
J (Type IV)	[illegible]	1.1	[illegible]
K (Type IV)	[illegible]	[illegible]	[illegible]
L (Type IV)	[illegible]	[illegible]	[illegible]
M (Type IV)	N/A	N/A	[illegible]
N (Type IV)	N/A	N/A	[illegible]

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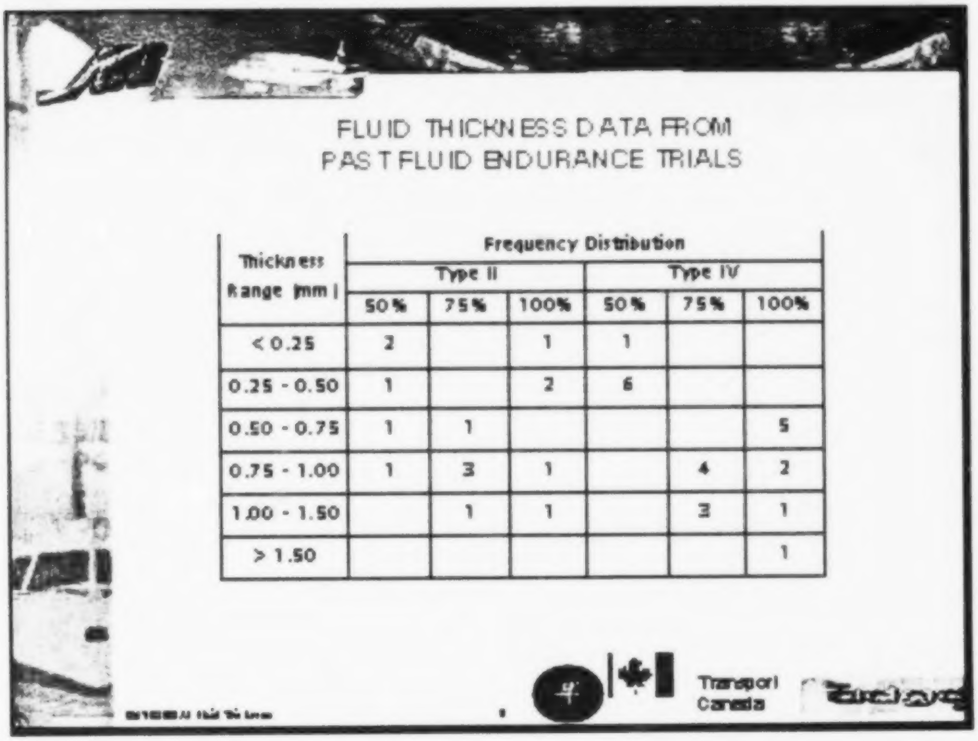

FLUID THICKNESS DATA FROM PAST FLUID ENDURANCE TRIALS

Thickness Range (mm)	Frequency Distribution					
	Type II			Type IV		
	50%	75%	100%	50%	75%	100%
< 0.25	2		1	1		
0.25 - 0.50	1		2	6		
0.50 - 0.75	1	1				5
0.75 - 1.00	1	3	1		4	2
1.00 - 1.50		1	1		3	1
> 1.50						1

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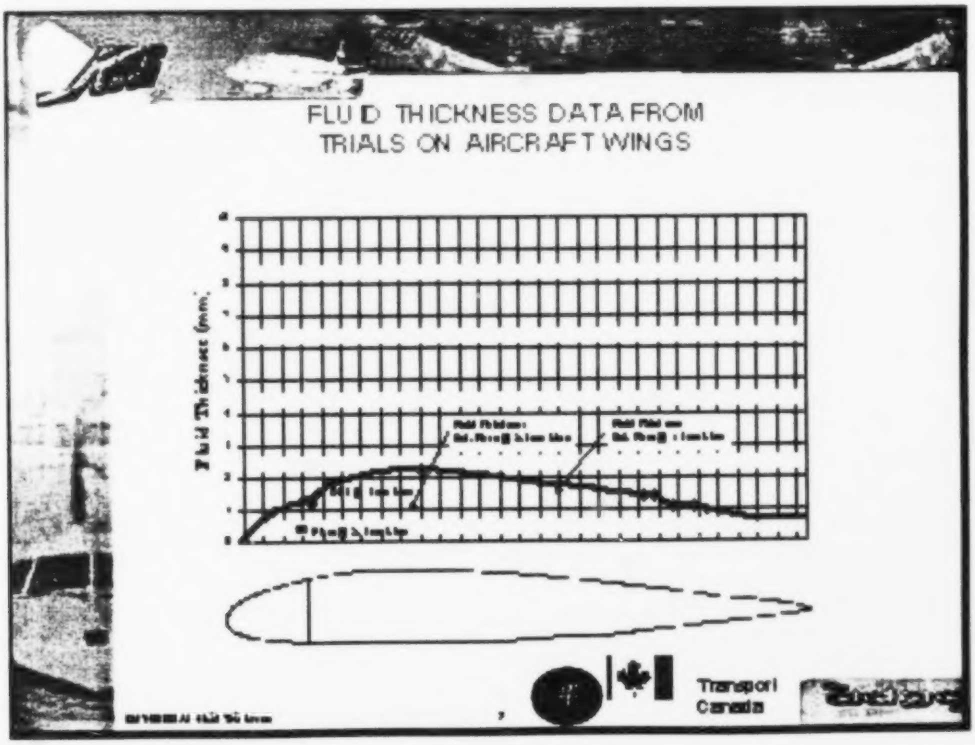

FLUID THICKNESS DATA FROM TRIALS ON AIRCRAFT WINGS

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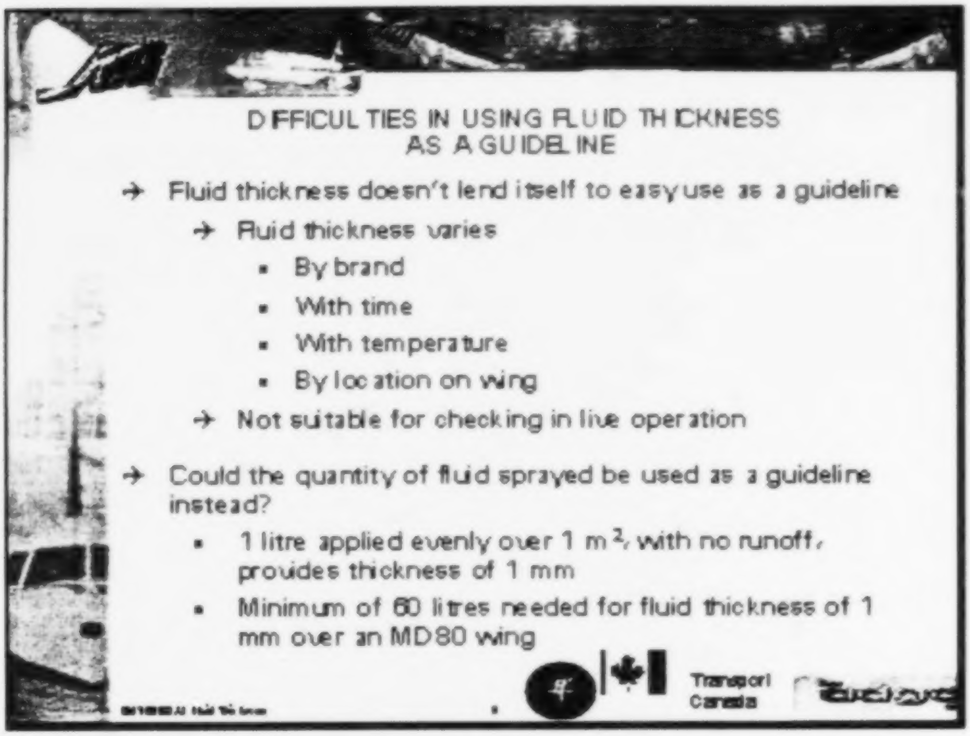
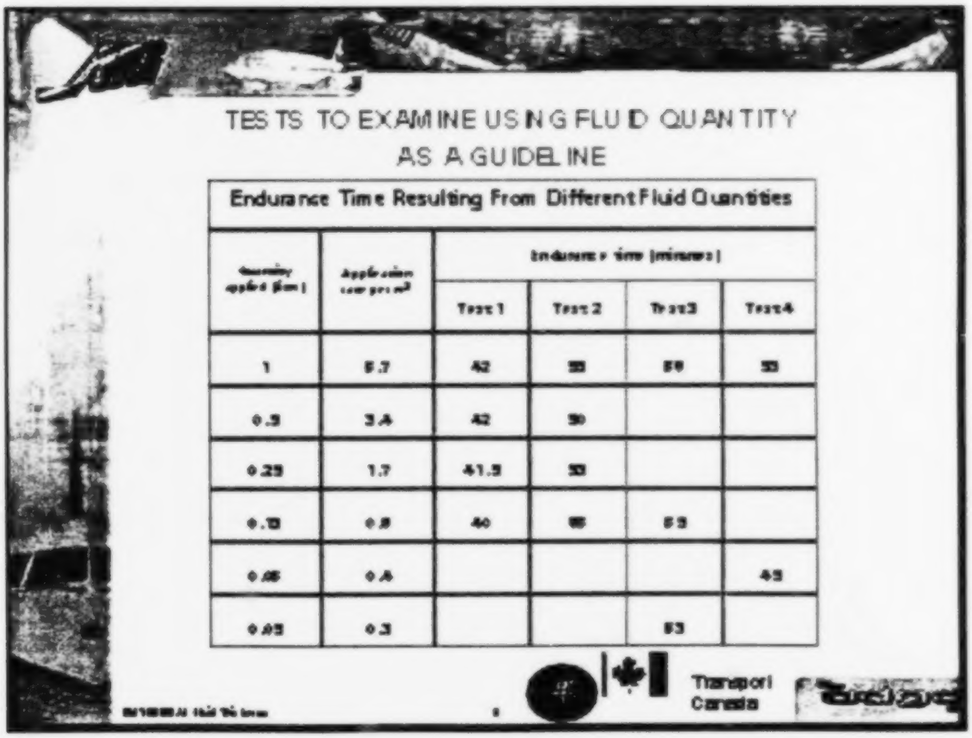


DIFFICULTIES IN USING FLUID THICKNESS AS A GUIDELINE

- → Fluid thickness doesn't lend itself to easy use as a guideline
  - → Fluid thickness varies
    - By brand
    - With time
    - With temperature
    - By location on wing
  - → Not suitable for checking in live operation
- → Could the quantity of fluid sprayed be used as a guideline instead?
  - 1 litre applied evenly over 1 m², with no runoff, provides thickness of 1 mm
  - Minimum of 60 litres needed for fluid thickness of 1 mm over an MD80 wing

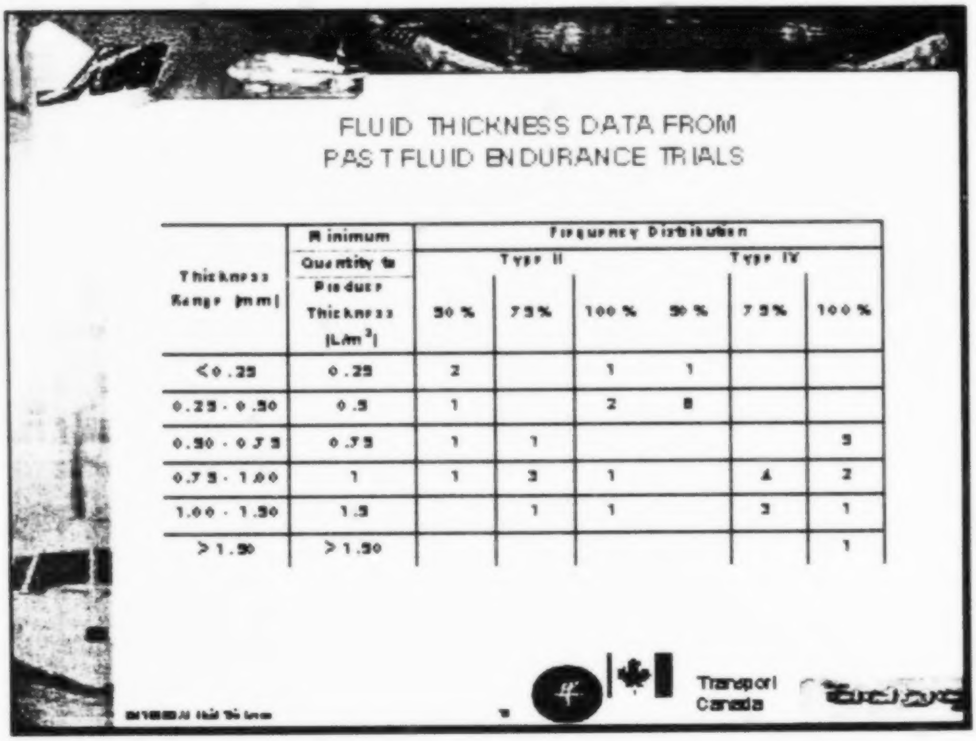
Transport Canada



TESTS TO EXAMINE USING FLUID QUANTITY AS A GUIDELINE

Endurance Time Resulting From Different Fluid Quantities					
Quantity applied ([illegible])	Application [illegible] per m²	Endurance time (minutes)			
		Test 1	Test 2	Test 3	Test 4
1	5.7	42	55	59	53
0.5	3.4	42	50		
0.25	1.7	41.5	53		
0.15	0.9	40	55	53	
0.08	0.4				45
0.05	0.3			53	

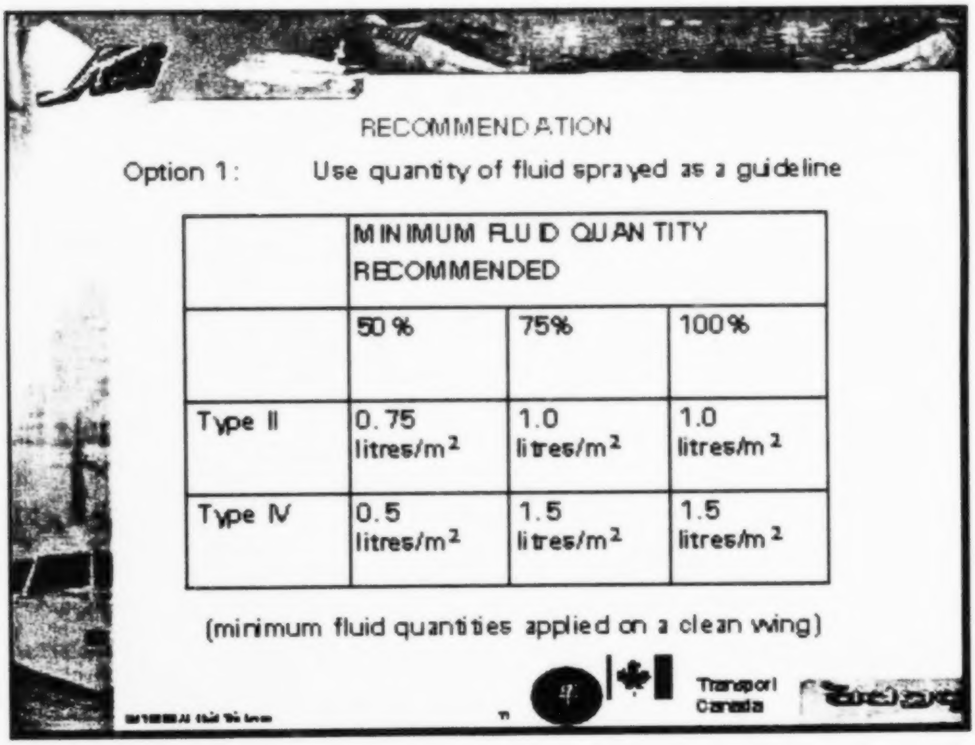
Transport Canada



FLUID THICKNESS DATA FROM PAST FLUID ENDURANCE TRIALS

Thickness Range (mm)	Minimum Quantity to Produce Thickness (L/m²)	Frequency Distribution					
		Type II			Type IV		
		50 %	75%	100 %	50 %	75%	100 %
<0.25	0.25	2		1	1		
0.25 - 0.50	0.5	1		2	8		
0.50 - 0.75	0.75	1	1				5
0.75 - 1.00	1	1	3	1		4	2
1.00 - 1.50	1.5		1	1		3	1
>1.50	>1.50						1

Transport Canada



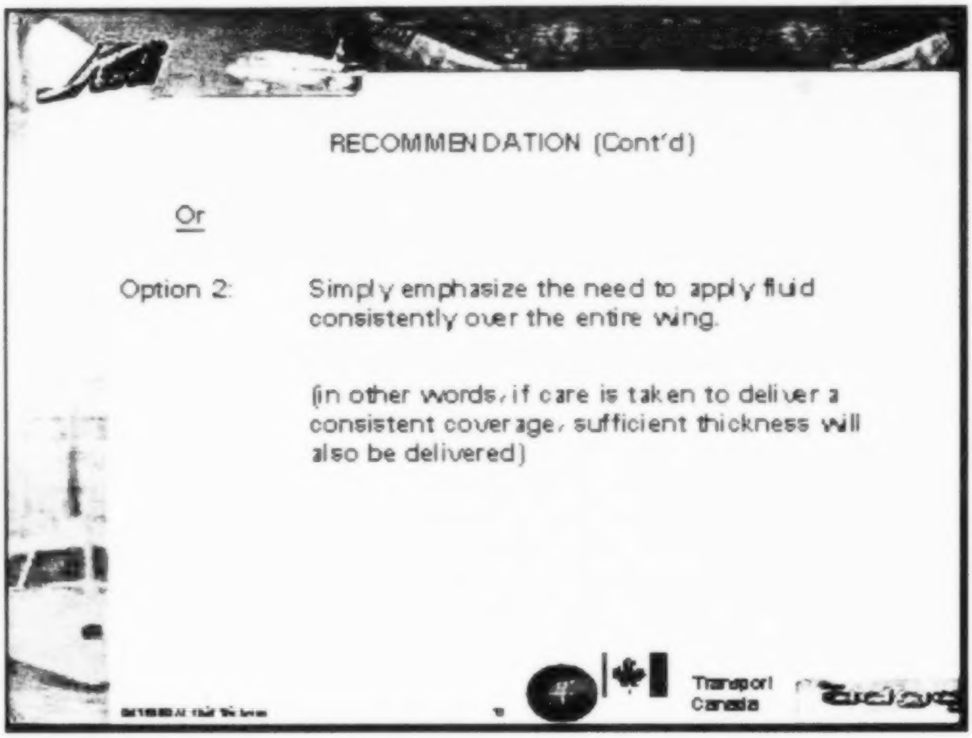
RECOMMENDATION

Option 1: Use quantity of fluid sprayed as a guideline

	MINIMUM FLUID QUANTITY RECOMMENDED		
	50 %	75%	100 %
Type II	0.75 litres/m^2	1.0 litres/m^2	1.0 litres/m^2
Type IV	0.5 litres/m^2	1.5 litres/m^2	1.5 litres/m^2

(minimum fluid quantities applied on a clean wing)

Transport Canada



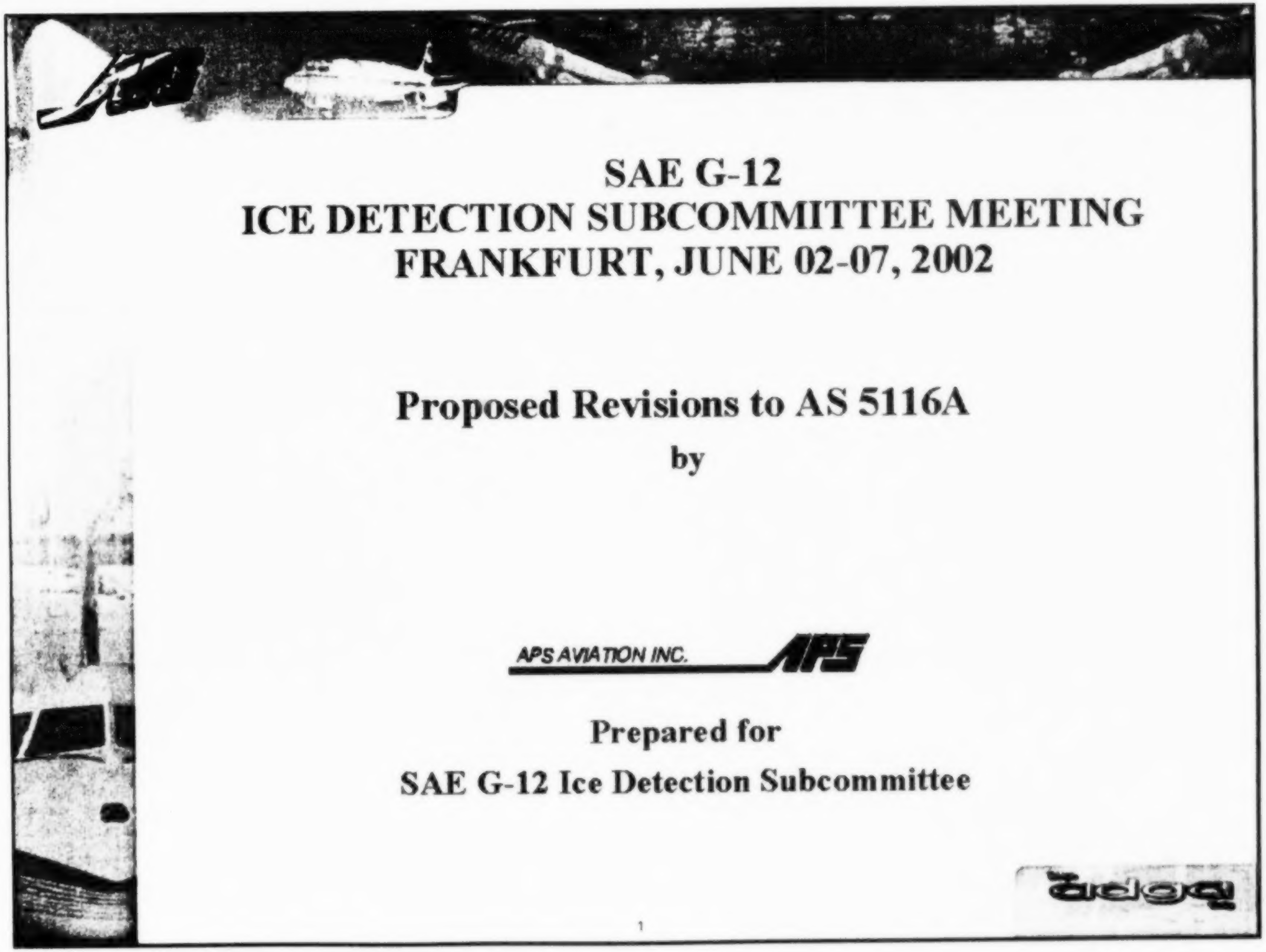
RECOMMENDATION (Cont'd)

Or

Option 2: Simply emphasize the need to apply fluid consistently over the entire wing.

(in other words, if care is taken to deliver a consistent coverage, sufficient thickness will also be delivered)

4
Transport
Canada



SAE G-12
ICE DETECTION SUBCOMMITTEE MEETING
FRANKFURT, JUNE 02-07, 2002

Proposed Revisions to AS 5116A

by

APS AVIATION INC.

Prepared for

SAE G-12 Ice Detection Subcommittee

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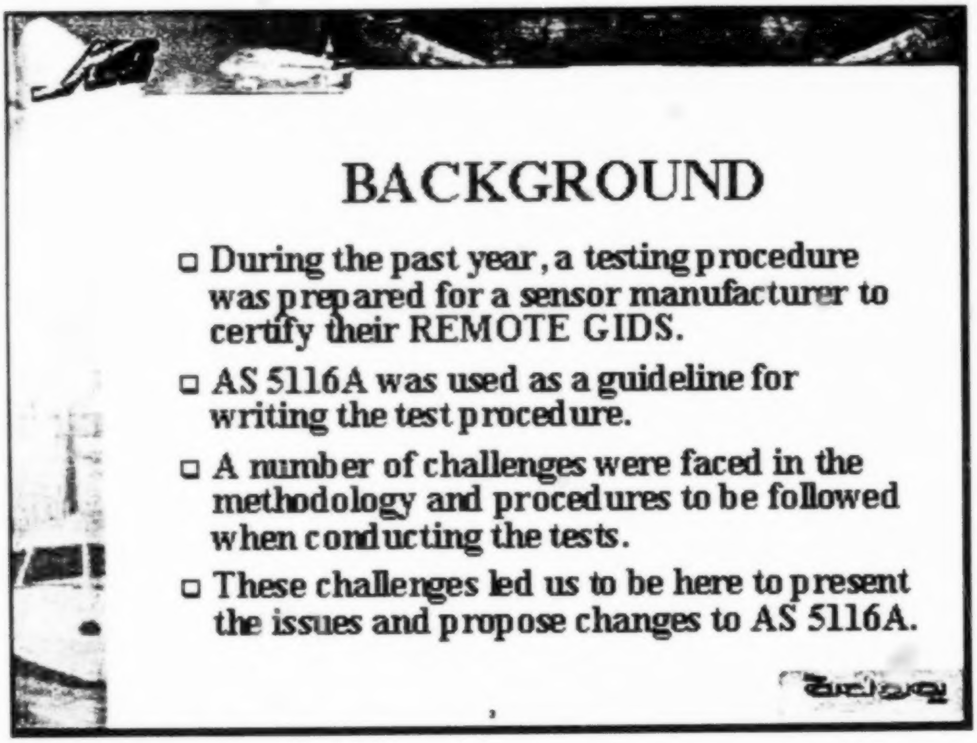
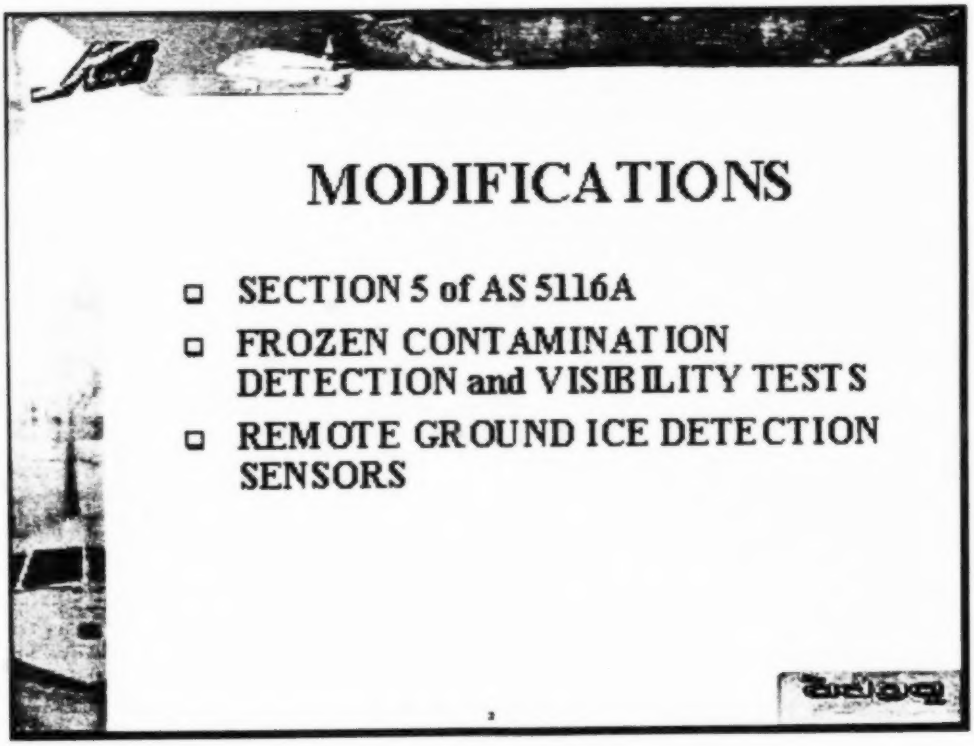


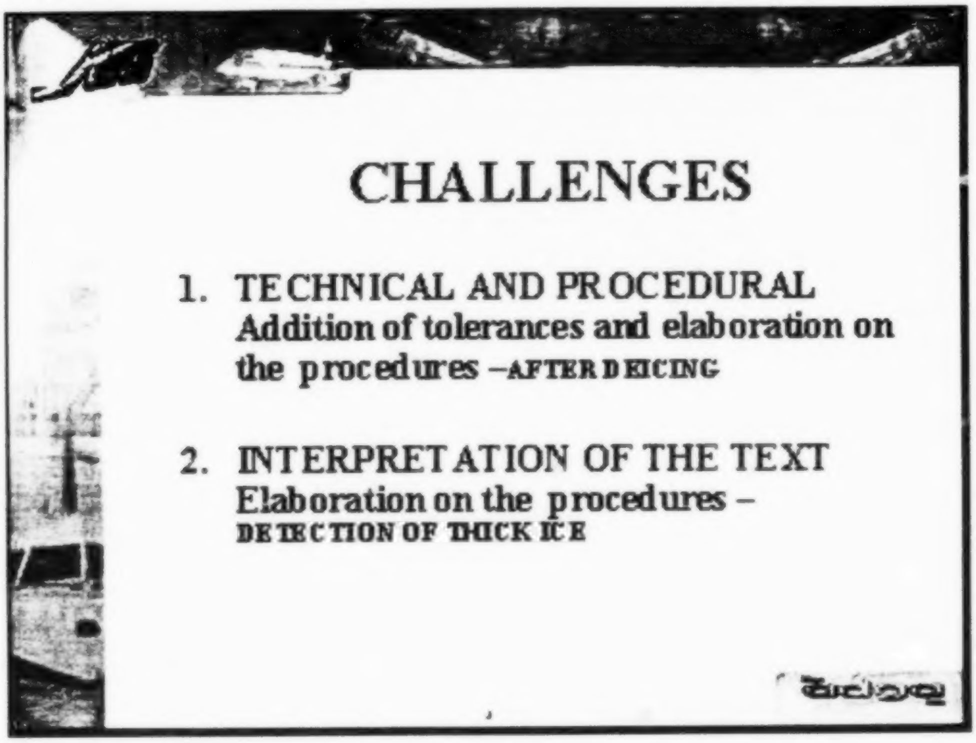
BACKGROUND

- During the past year, a testing procedure was prepared for a sensor manufacturer to certify their REMOTE GIDS.
- AS 5116A was used as a guideline for writing the test procedure.
- A number of challenges were faced in the methodology and procedures to be followed when conducting the tests.
- These challenges led us to be here to present the issues and propose changes to AS 5116A.



MODIFICATIONS

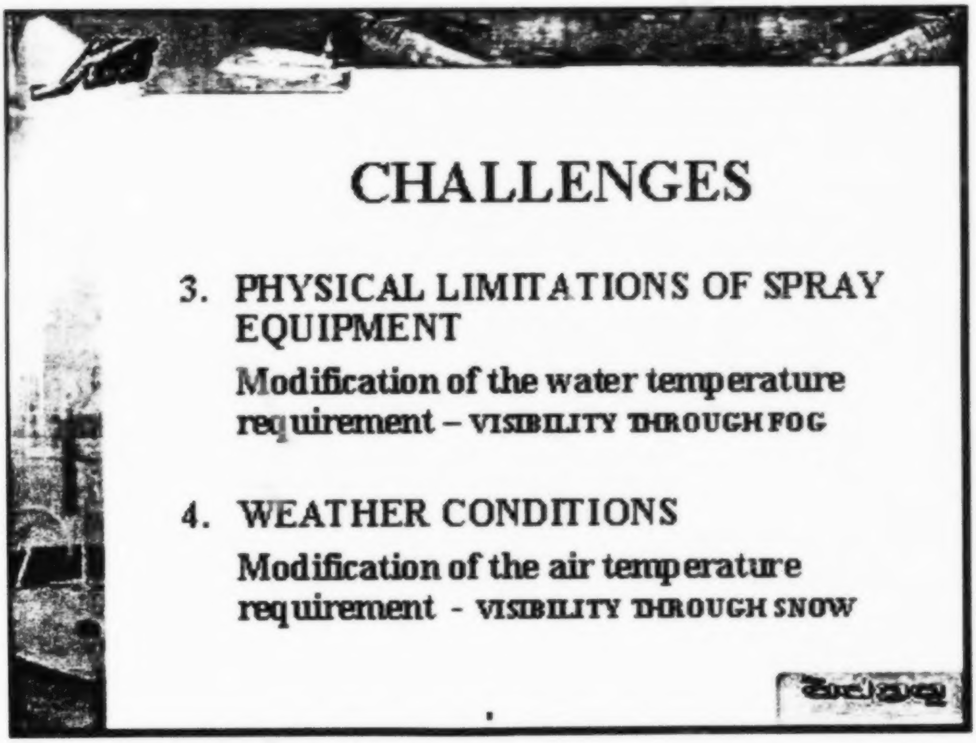
- SECTION 5 of AS 5116A
- FROZEN CONTAMINATION DETECTION and VISIBILITY TESTS
- REMOTE GROUND ICE DETECTION SENSORS



CHALLENGES

1. TECHNICAL AND PROCEDURAL
   Addition of tolerances and elaboration on the procedures –AFTER DEICING

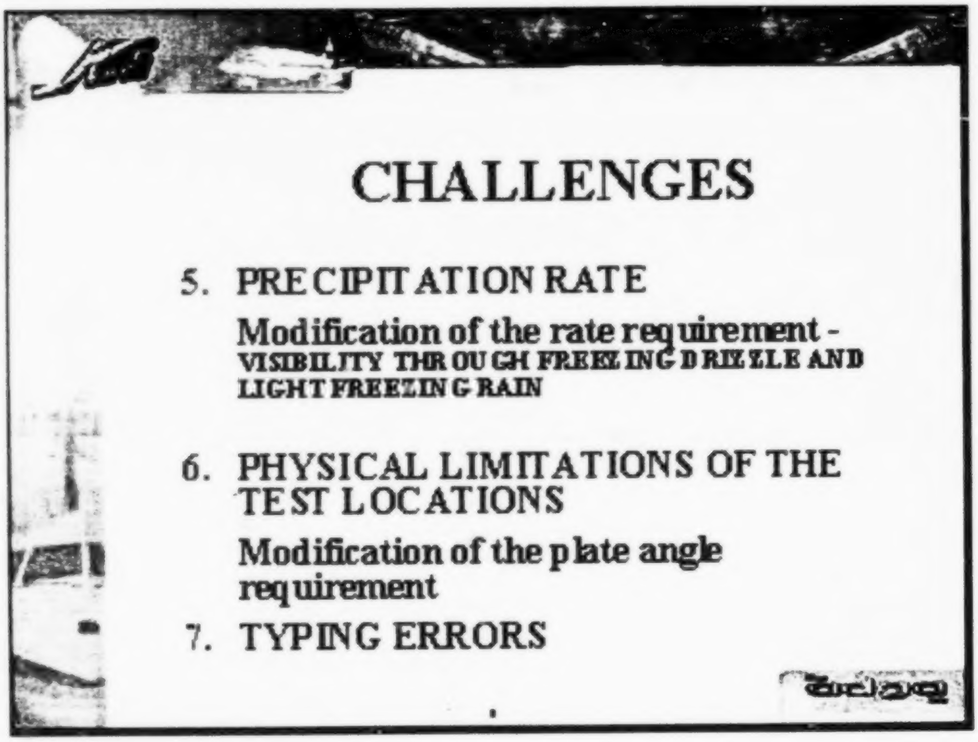
2. INTERPRETATION OF THE TEXT
   Elaboration on the procedures – DETECTION OF THICK ICE



CHALLENGES

3. PHYSICAL LIMITATIONS OF SPRAY EQUIPMENT
   Modification of the water temperature requirement – VISIBILITY THROUGH FOG

4. WEATHER CONDITIONS
   Modification of the air temperature requirement - VISIBILITY THROUGH SNOW



CHALLENGES

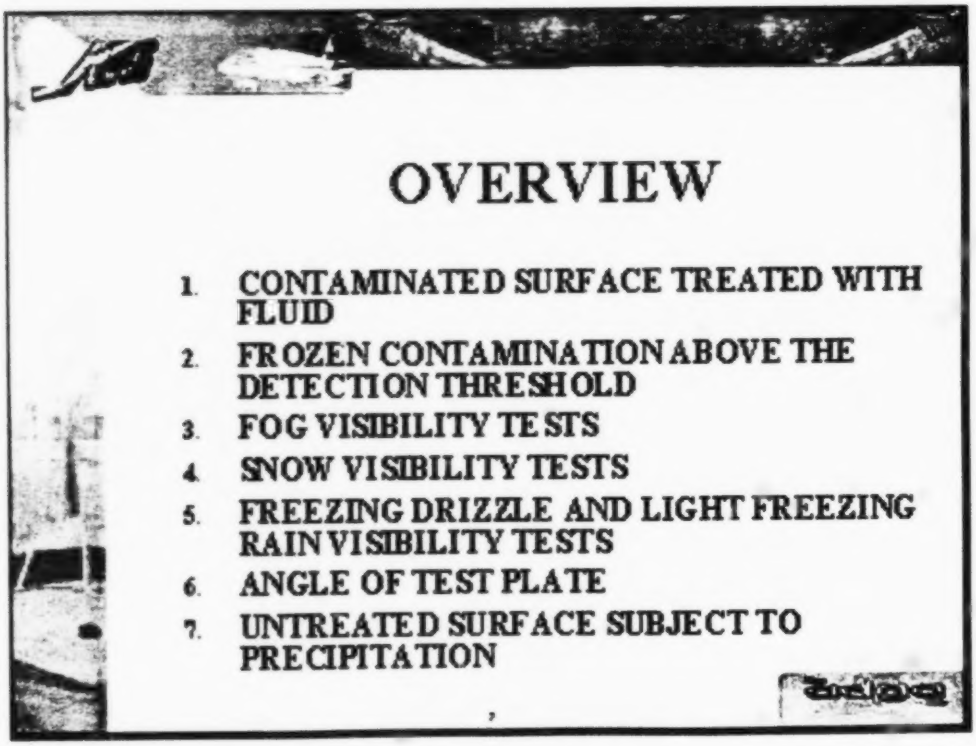
5. PRECIPITATION RATE

   Modification of the rate requirement - VISIBILITY THROUGH FREEZING DRIZZLE AND LIGHT FREEZING RAIN

6. PHYSICAL LIMITATIONS OF THE TEST LOCATIONS

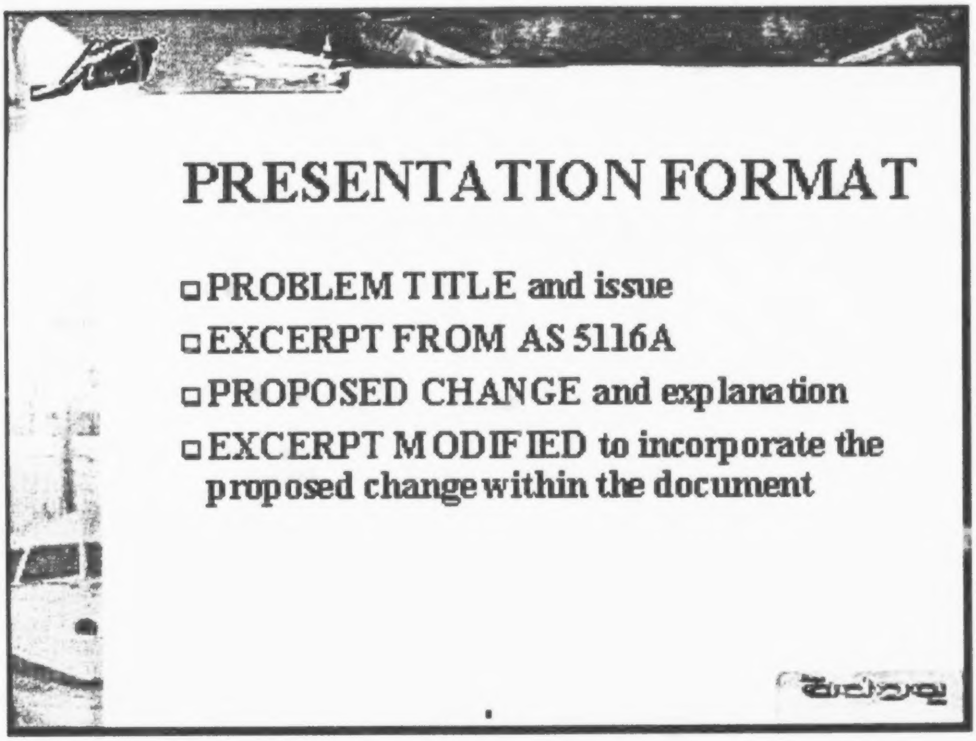
   Modification of the plate angle requirement

7. TYPING ERRORS



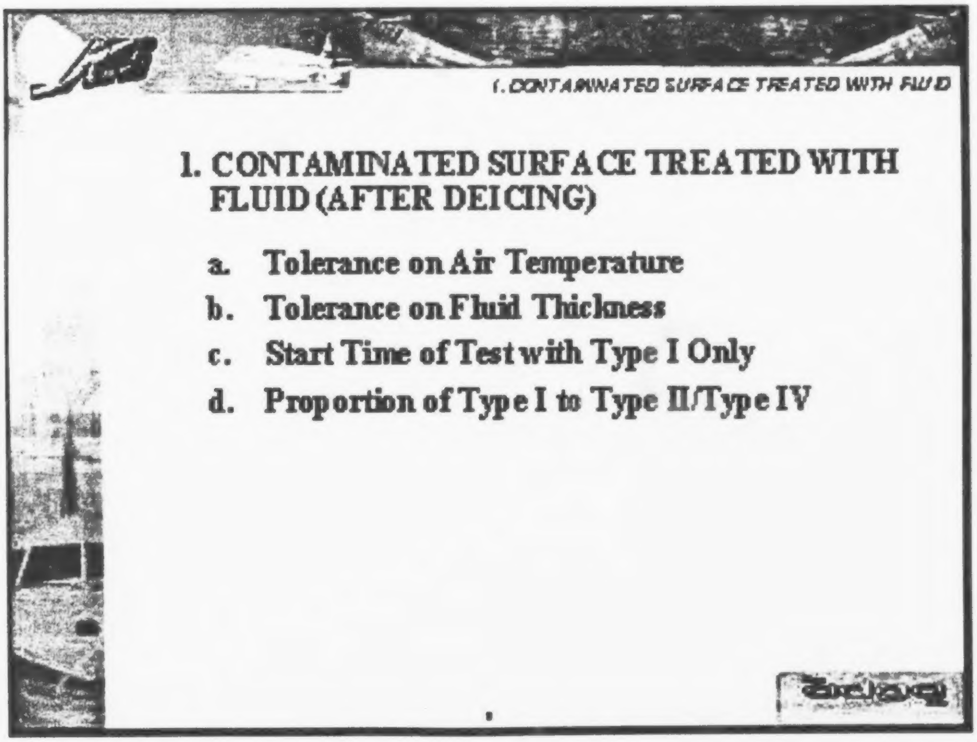
OVERVIEW

1. CONTAMINATED SURFACE TREATED WITH FLUID
2. FROZEN CONTAMINATION ABOVE THE DETECTION THRESHOLD
3. FOG VISIBILITY TESTS
4. SNOW VISIBILITY TESTS
5. FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS
6. ANGLE OF TEST PLATE
7. UNTREATED SURFACE SUBJECT TO PRECIPITATION



PRESENTATION FORMAT

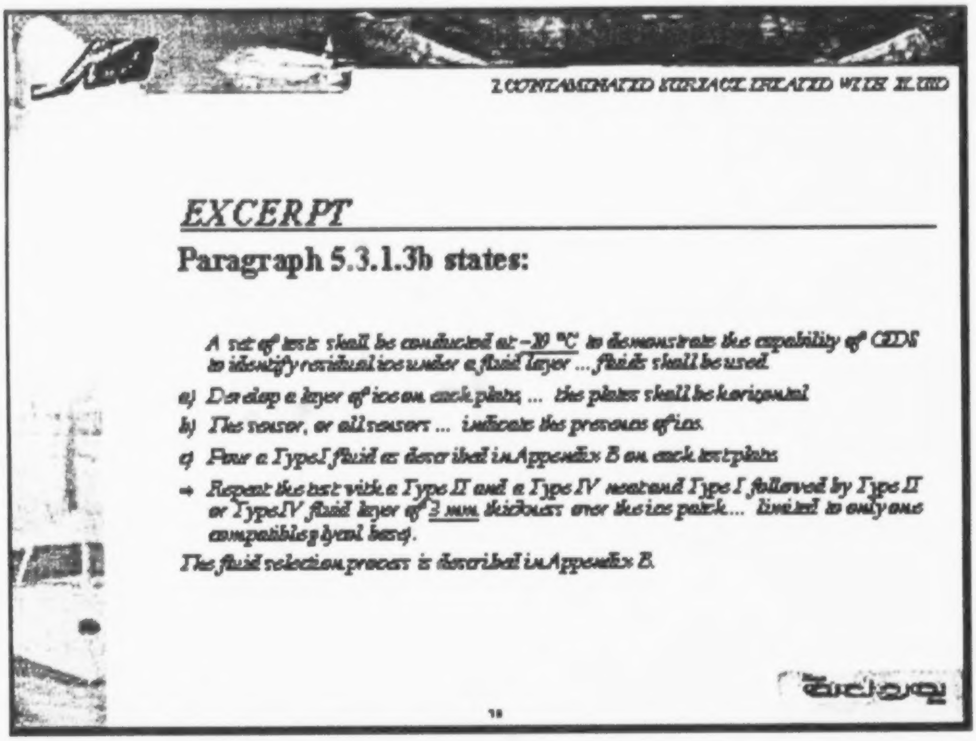
- ☐ PROBLEM TITLE and issue
- ☐ EXCERPT FROM AS 5116A
- ☐ PROPOSED CHANGE and explanation
- ☐ EXCERPT MODIFIED to incorporate the proposed change within the document



1. CONTAMINATED SURFACE TREATED WITH FLUID

1. CONTAMINATED SURFACE TREATED WITH FLUID (AFTER DEICING)

a. Tolerance on Air Temperature
b. Tolerance on Fluid Thickness
c. Start Time of Test with Type I Only
d. Proportion of Type I to Type II/Type IV



1. CONTAMINATED SURFACE TREATED WITH FLUID

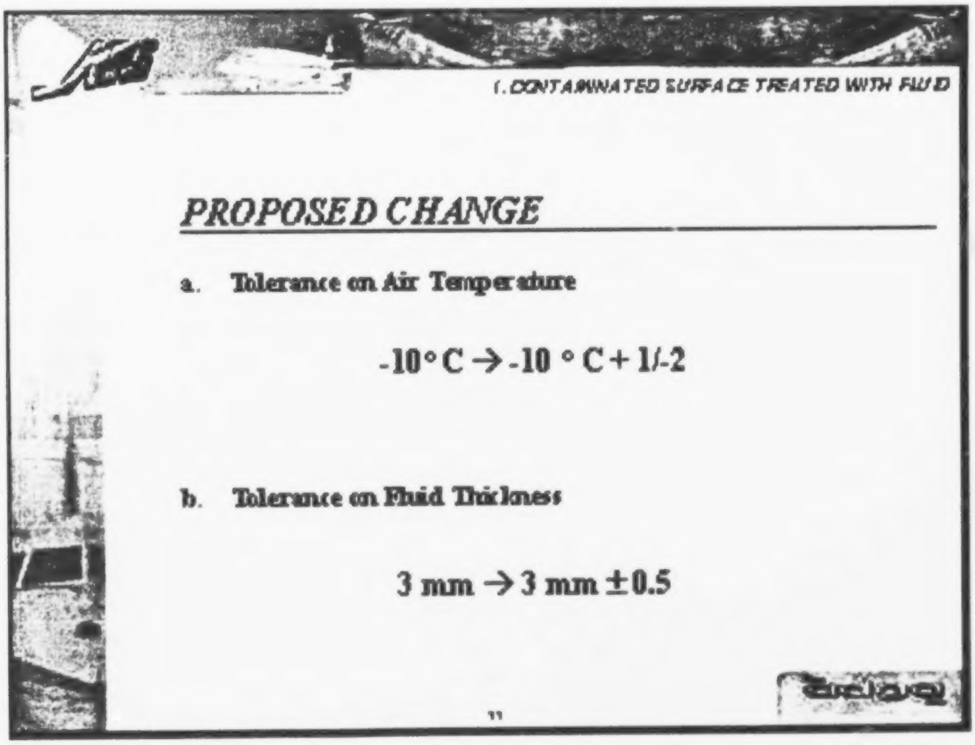
EXCERPT

Paragraph 5.3.1.3b states:

A set of tests shall be conducted at -10 °C to demonstrate the capability of CIDS to identify residual ice under a fluid layer ... fluids shall be used.

- *a) Develop a layer of ice on each plate; ... the plates shall be horizontal*
- *b) The sensor, or all sensors ... indicate the presence of ice.*
- *c) Pour a Type I fluid as described in Appendix B on each test plate*
- ➡ *Repeat the test with a Type II and a Type IV neat and Type I followed by Type II or Type IV fluid layer of 3 mm thickness over the ice patch... limited to only one compatible glycol base).*

The fluid selection process is described in Appendix B.



1. CONTAMINATED SURFACE TREATED WITH FLUID

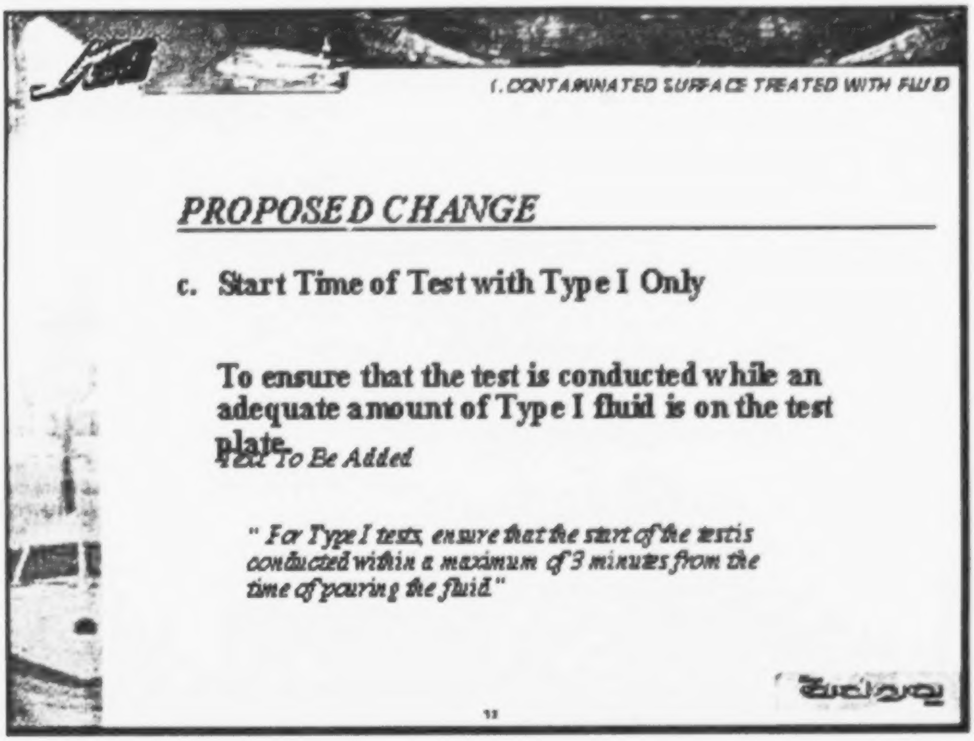
PROPOSED CHANGE

a. **Tolerance on Air Temperature**

-10 ° C → -10 ° C + 1/-2

b. **Tolerance on Fluid Thickness**

3 mm → 3 mm ±0.5



I. CONTAMINATED SURFACE TREATED WITH FLUID

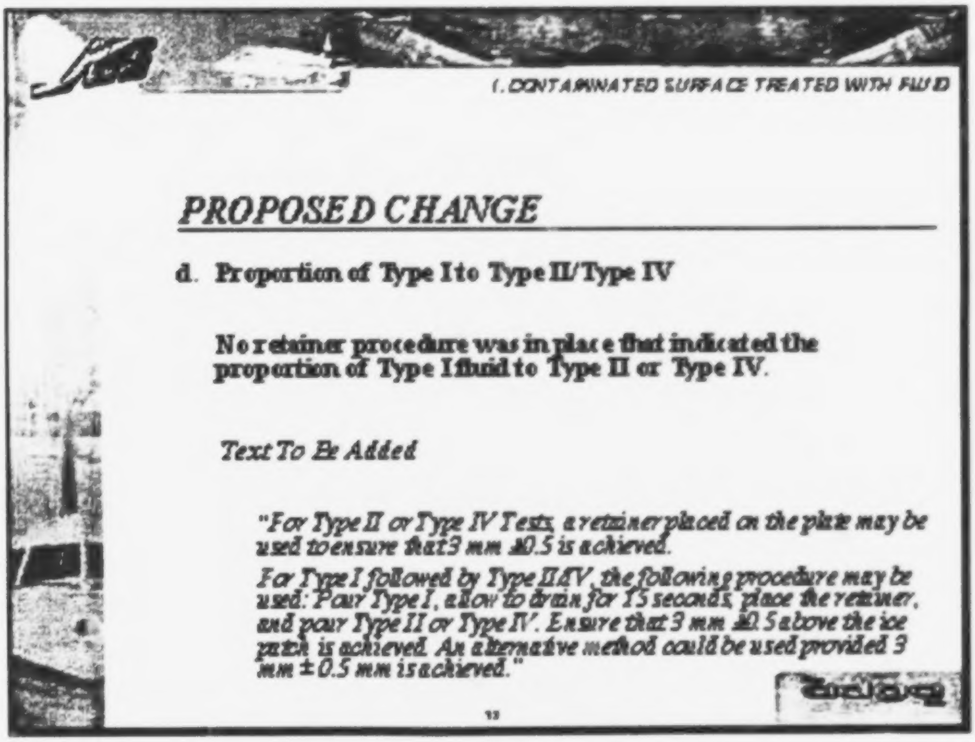
PROPOSED CHANGE

c. Start Time of Test with Type I Only

To ensure that the test is conducted while an adequate amount of Type I fluid is on the test plate.

Text To Be Added

" For Type I tests, ensure that the start of the test is conducted within a maximum of 3 minutes from the time of pouring the fluid."



I. CONTAMINATED SURFACE TREATED WITH FLUID

PROPOSED CHANGE

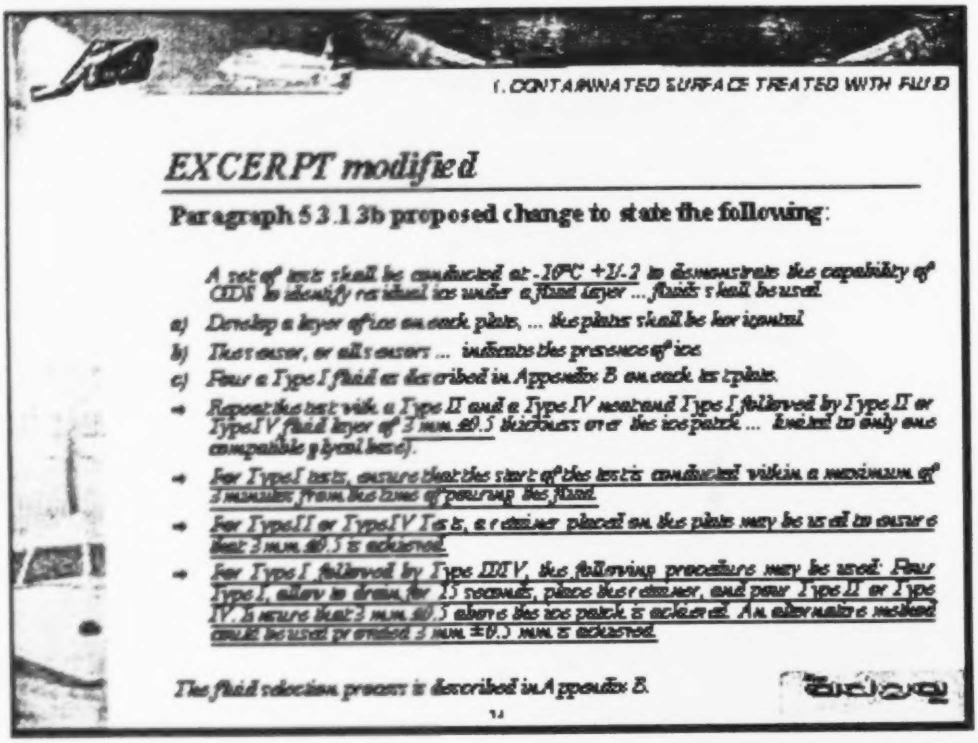
d. Proportion of Type I to Type II/Type IV

No retainer procedure was in place that indicated the proportion of Type I fluid to Type II or Type IV.

Text To Be Added

"For Type II or Type IV Tests, a retainer placed on the plate may be used to ensure that 3 mm ±0.5 is achieved.

For Type I followed by Type II&IV, the following procedure may be used: Pour Type I, allow to drain for 15 seconds, place the retainer, and pour Type II or Type IV. Ensure that 3 mm ±0.5 above the ice patch is achieved. An alternative method could be used provided 3 mm ± 0.5 mm is achieved."



1. CONTAMINATED SURFACE TREATED WITH FLUID

EXCERPT modified

Paragraph 5.3.1.3b proposed change to state the following:

A set of tests shall be conducted at -10°C +/-2 to demonstrate the capability of CIDS to identify residual ice under a fluid layer ... fluids shall be used.

a) Develop a layer of ice on each plate, ... the plates shall be horizontal.

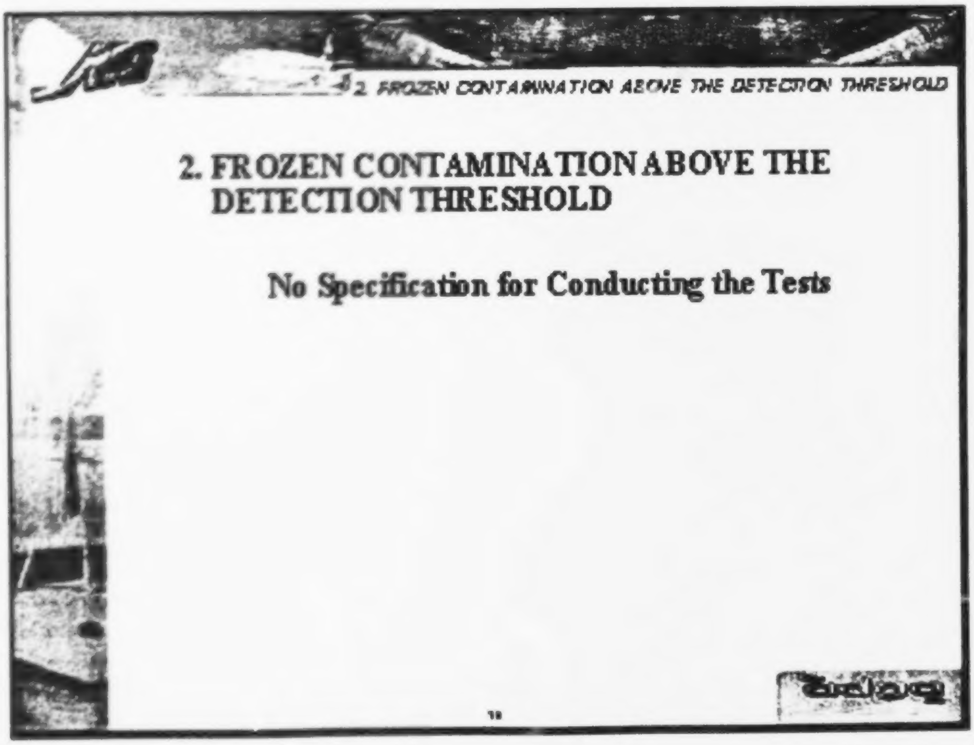
b) The sensor, or all sensors ... indicate the presence of ice.

c) Pour a Type I fluid as described in Appendix B on each test plate.

- → *Repeat the test with a Type II and a Type IV neat and Type I followed by Type II or Type IV fluid layer of 3 mm ±0.5 thickness over the ice patch ... limited to only one compatible glycol base).*
- → *For Type I tests, ensure that the start of the test is conducted within a maximum of 3 minutes from the time of pouring the fluid.*
- → *For Type II or Type IV Tests, a retainer placed on the plate may be used to ensure that 3 mm ±0.5 is achieved.*
- → *For Type I followed by Type II/IV, the following procedure may be used: Pour Type I, allow to drain for 15 seconds, place the retainer, and pour Type II or Type IV. Ensure that 3 mm ±0.5 above the ice patch is achieved. An alternative method could be used provided 3 mm ±0.5 mm is achieved.*

The fluid selection process is described in Appendix B.

34

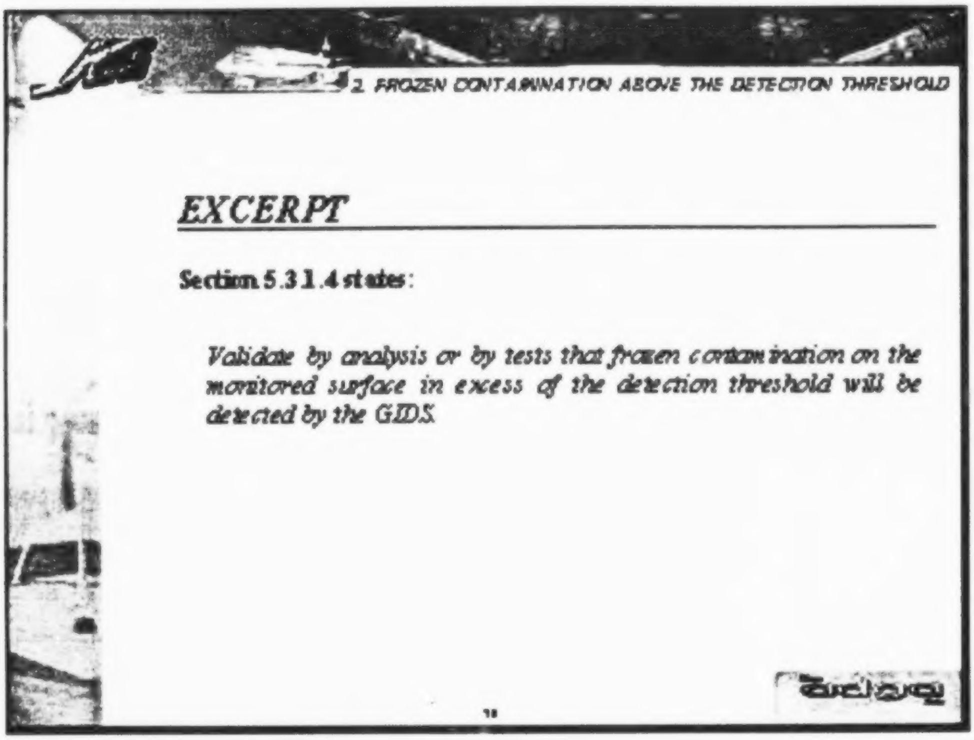


2. FROZEN CONTAMINATION ABOVE THE DETECTION THRESHOLD

2. FROZEN CONTAMINATION ABOVE THE DETECTION THRESHOLD

No Specification for Conducting the Tests

35

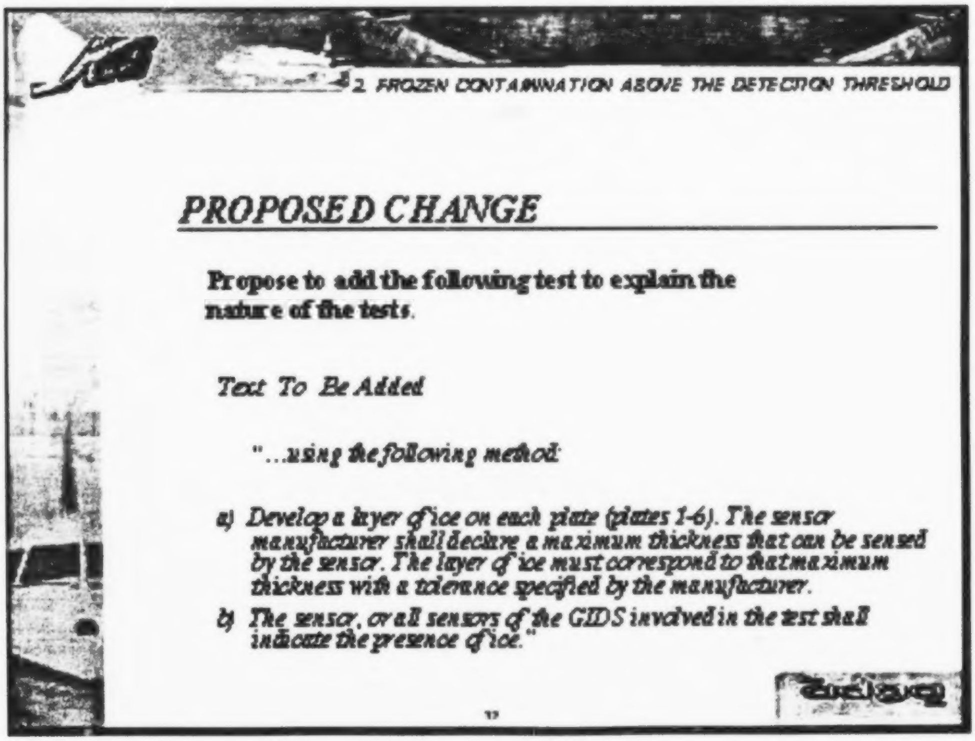


2. FROZEN CONTAMINATION ABOVE THE DETECTION THRESHOLD

EXCERPT

Section 5.3.1.4 states:

Validate by analysis or by tests that frozen contamination on the monitored surface in excess of the detection threshold will be detected by the GIDS.



2. FROZEN CONTAMINATION ABOVE THE DETECTION THRESHOLD

PROPOSED CHANGE

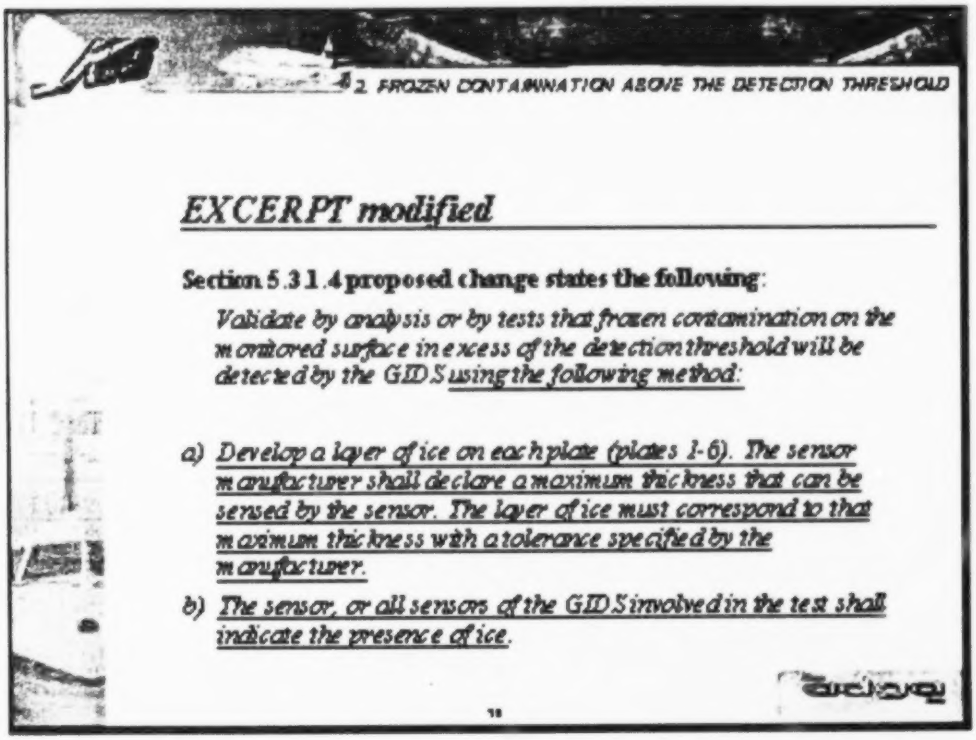
Propose to add the following test to explain the nature of the tests.

Text To Be Added

"...using the following method:

a) Develop a layer of ice on each plate (plates 1-6). The sensor manufacturer shall declare a maximum thickness that can be sensed by the sensor. The layer of ice must correspond to that maximum thickness with a tolerance specified by the manufacturer.

b) The sensor, or all sensors of the GIDS involved in the test shall indicate the presence of ice."



2. FROZEN CONTAMINATION ABOVE THE DETECTION THRESHOLD

EXCERPT modified

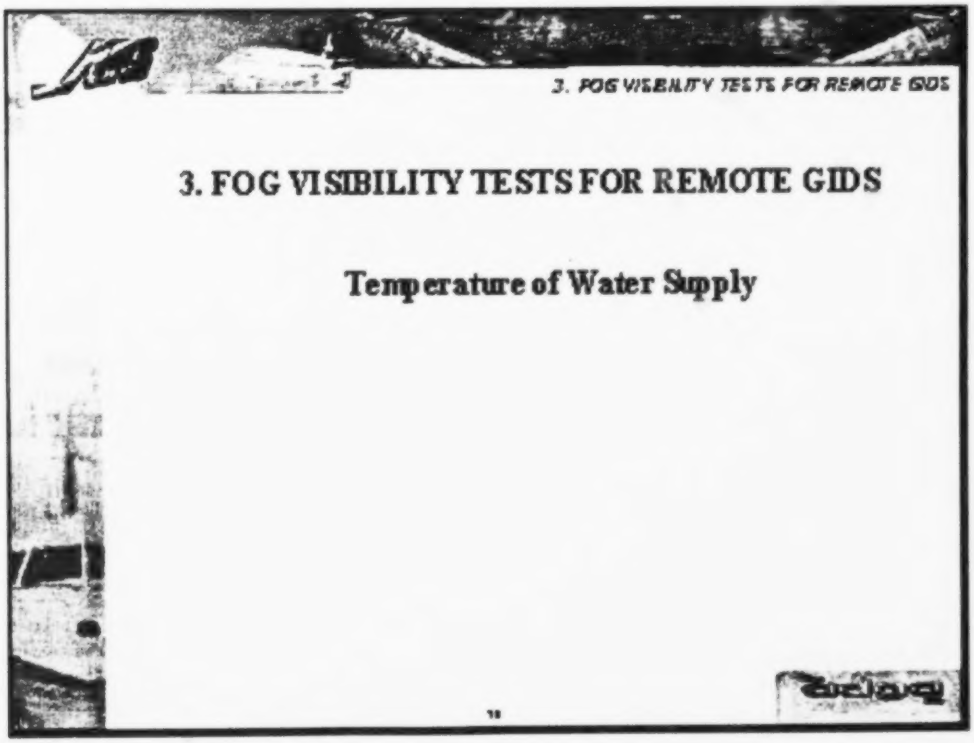
Section 5.3.1.4 proposed change states the following:

Validate by analysis or by tests that frozen contamination on the monitored surface in excess of the detection threshold will be detected by the GIDS using the following method:

a) *Develop a layer of ice on each plate (plates 1-6). The sensor manufacturer shall declare a maximum thickness that can be sensed by the sensor. The layer of ice must correspond to that maximum thickness with a tolerance specified by the manufacturer.*

b) *The sensor, or all sensors of the GIDS involved in the test shall indicate the presence of ice.*

aclavaq

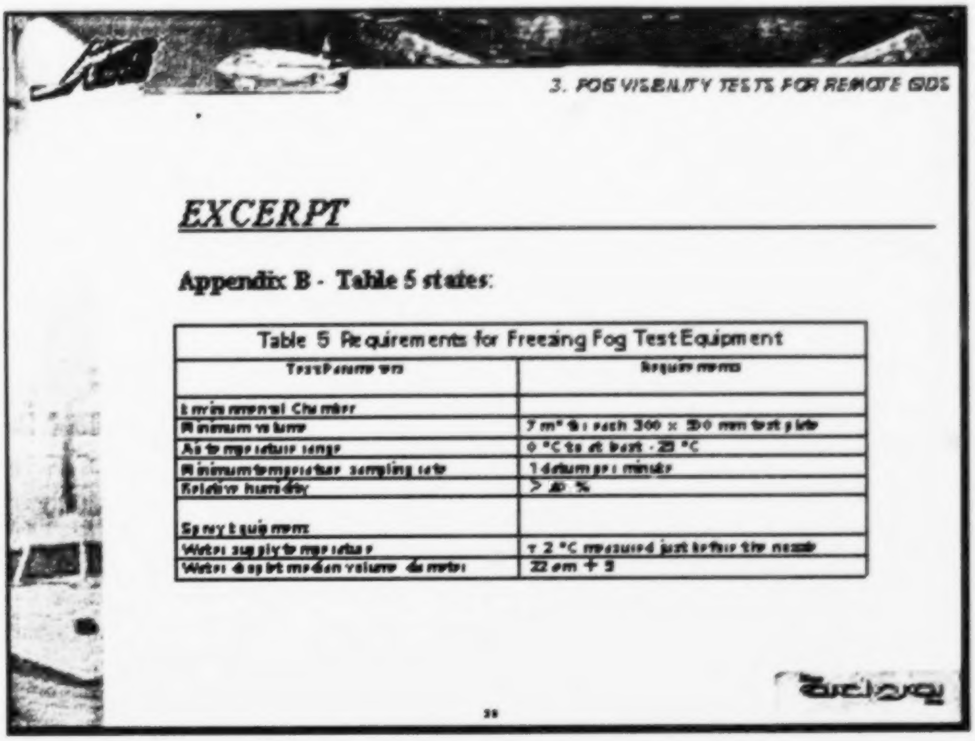


3. FOG VISIBILITY TESTS FOR REMOTE GIDS

3. FOG VISIBILITY TESTS FOR REMOTE GIDS

Temperature of Water Supply

aclavaq

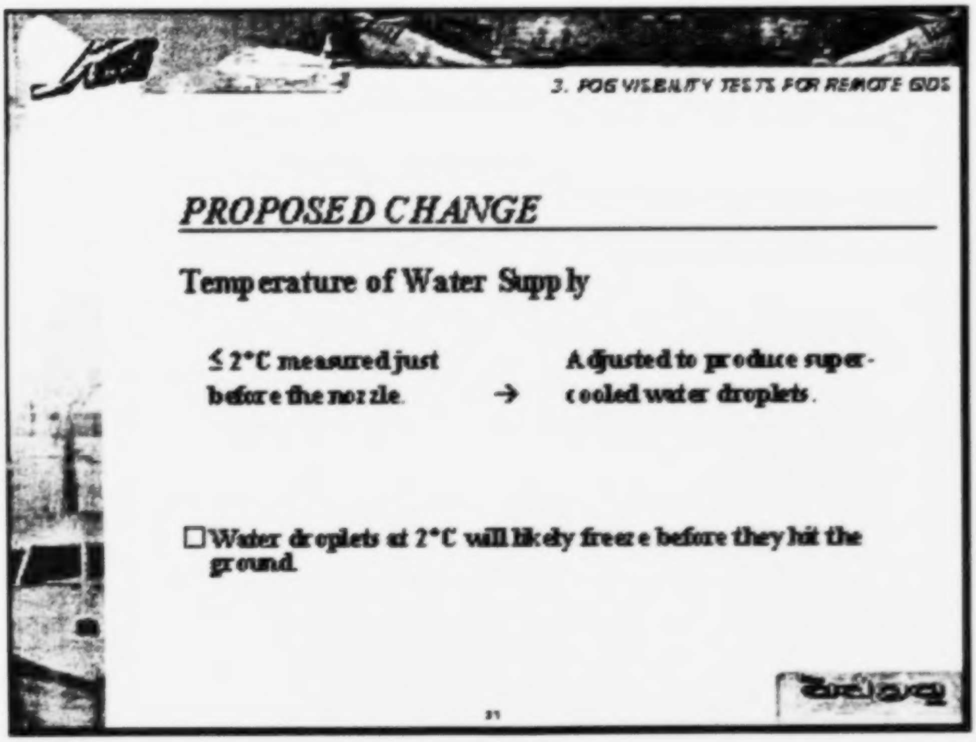


3. FOG VISIBILITY TESTS FOR REMOTE GIDS

EXCERPT

Appendix B - Table 5 states:

Table 5 Requirements for Freezing Fog Test Equipment	
Test Parameters	Requirements
Environmental Chamber	
Minimum volume	7 m³ for each 300 × 500 mm test plate
Air temperature range	0 °C to at least -25 °C
Minimum temperature sampling rate	1 datum per minute
Relative humidity	> [illegible] %
Spray Equipment	
Water supply temperature	≤ 2 °C measured just before the nozzle
Water droplet median volume diameter	22 µm ± 5



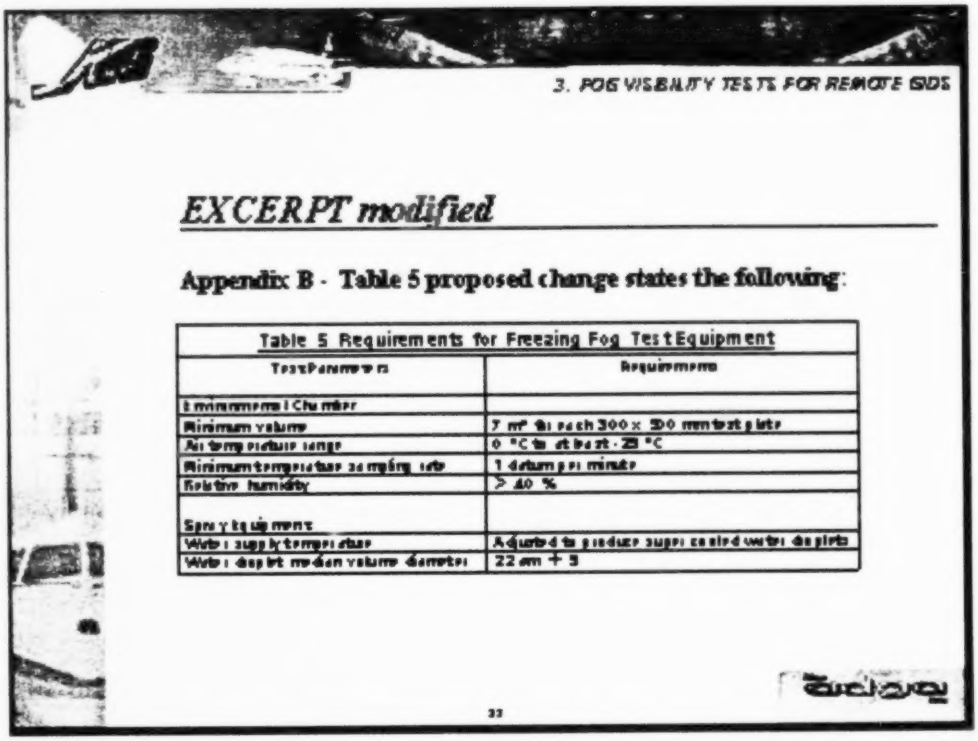
3. FOG VISIBILITY TESTS FOR REMOTE GIDS

PROPOSED CHANGE

Temperature of Water Supply

≤ 2°C measured just before the nozzle.	→	Adjusted to produce super-cooled water droplets.

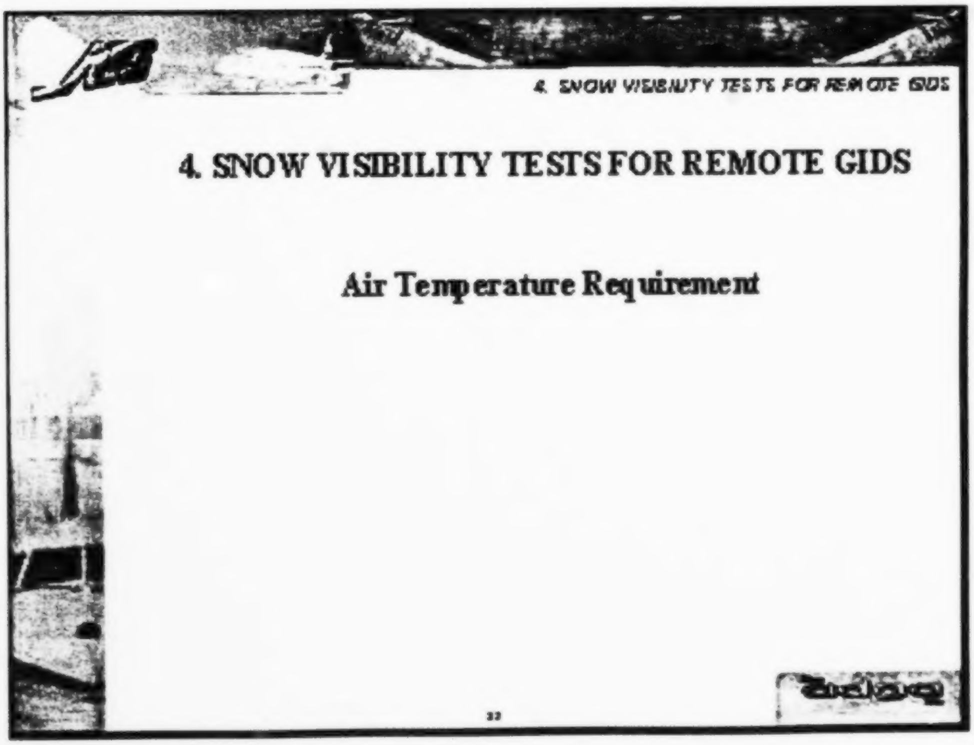
☐ Water droplets at 2°C will likely freeze before they hit the ground.



EXCERPT modified

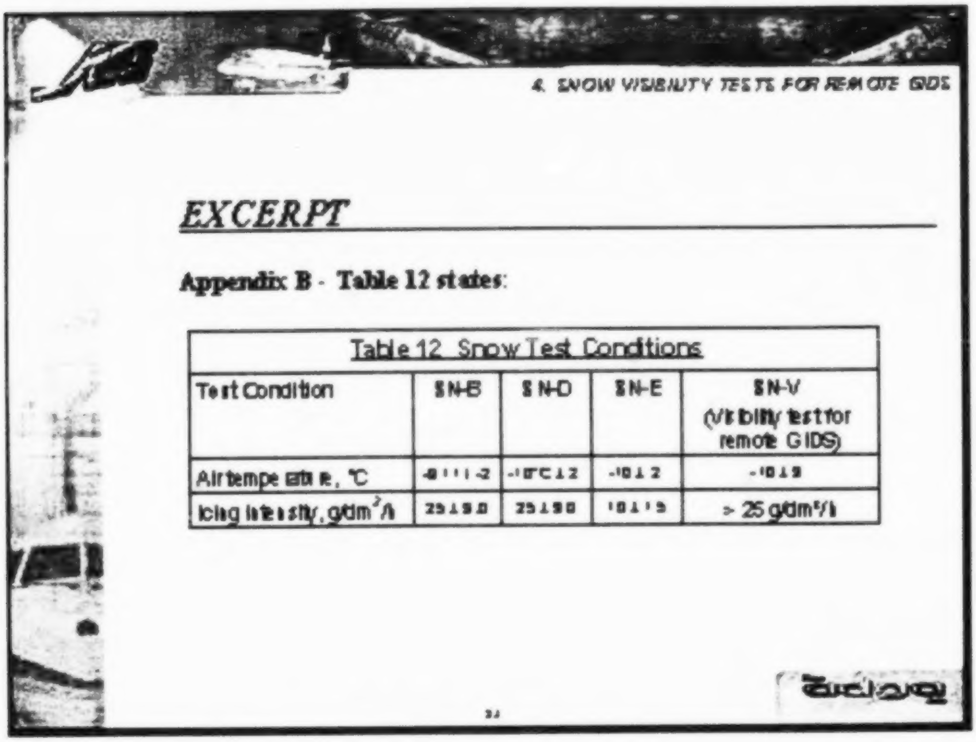
Appendix B - Table 5 proposed change states the following:

Table 5 Requirements for Freezing Fog Test Equipment	
Test Parameters	Requirements
Environmental Chamber	
Minimum volume	7 m³ for each 300 × 500 mm test plate
Air temperature range	0 °C to at least -20 °C
Minimum temperature sampling rate	1 datum per minute
Relative humidity	> 40 %
Spray Equipment	
Water supply temperature	Adjusted to produce supercooled water droplets
Water droplet median volume diameter	22 µm + 3



4. SNOW VISIBILITY TESTS FOR REMOTE GIDS

Air Temperature Requirement

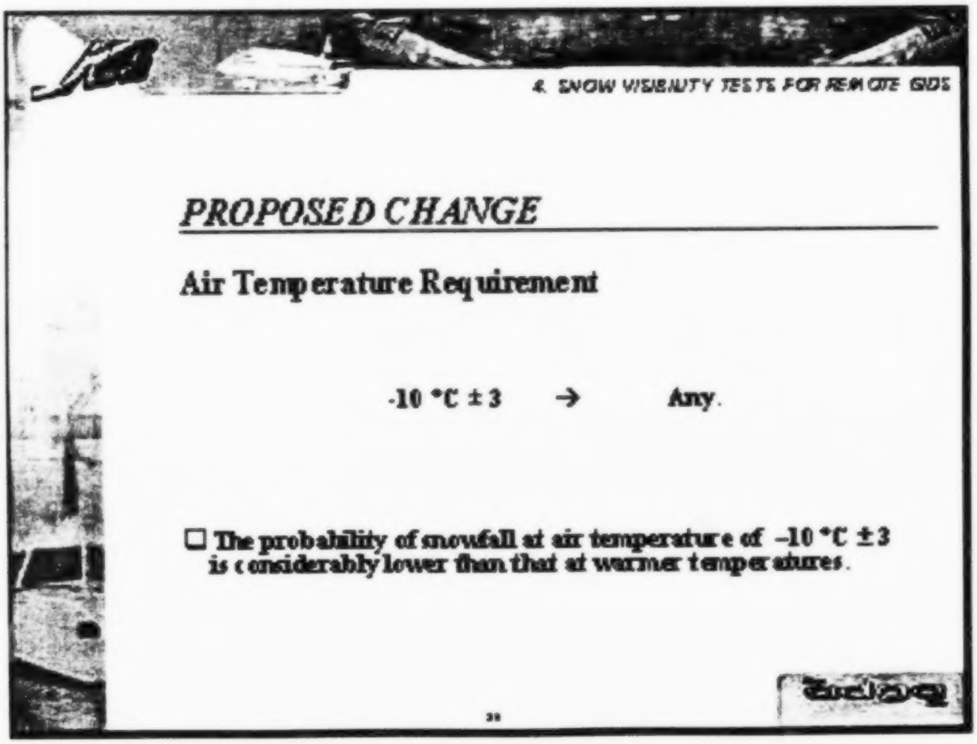


4. SNOW VISIBILITY TESTS FOR REMOTE GIDS

EXCERPT

Appendix B - Table 12 states:

Table 12 Snow Test Conditions				
Test Condition	SN-B	SN-D	SN-E	SN-V (Visibility test for remote GIDS)
Air temperature, °C	[illegible]	-10°C ± 2	-10 ± 2	-10 ± 3
Icing intensity, g/dm²/h	25 ± 5.0	25 ± 5.0	10 ± 1.5	> 25 g/dm²/h



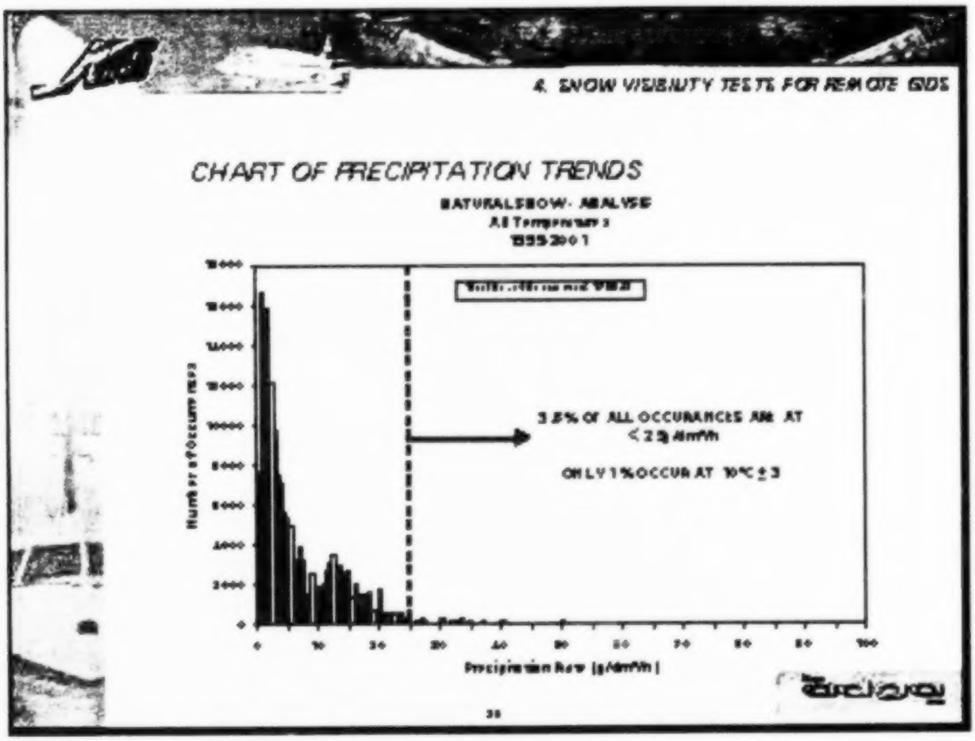
4. SNOW VISIBILITY TESTS FOR REMOTE GIDS

PROPOSED CHANGE

Air Temperature Requirement

-10 °C ± 3 → Any.

☐ The probability of snowfall at air temperature of -10 °C ± 3 is considerably lower than that at warmer temperatures.

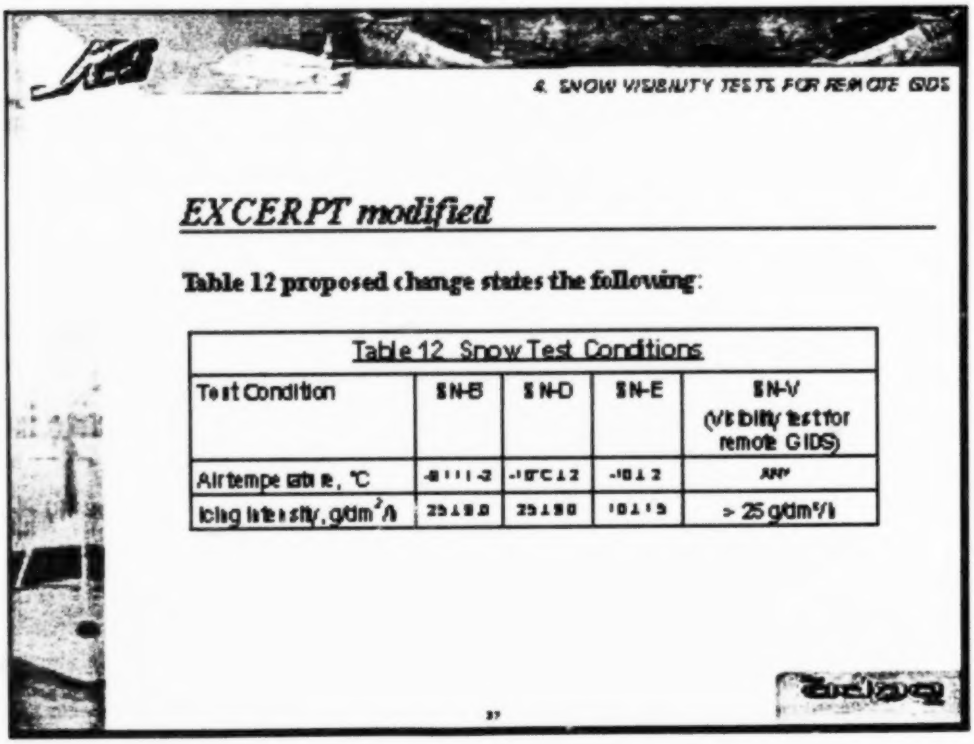


4. SNOW VISIBILITY TESTS FOR REMOTE GIDS

CHART OF PRECIPITATION TRENDS

3.5% OF ALL OCCURANCES ARE AT < 25 g/dm²/h

ONLY 1% OCCUR AT -10°C ± 3



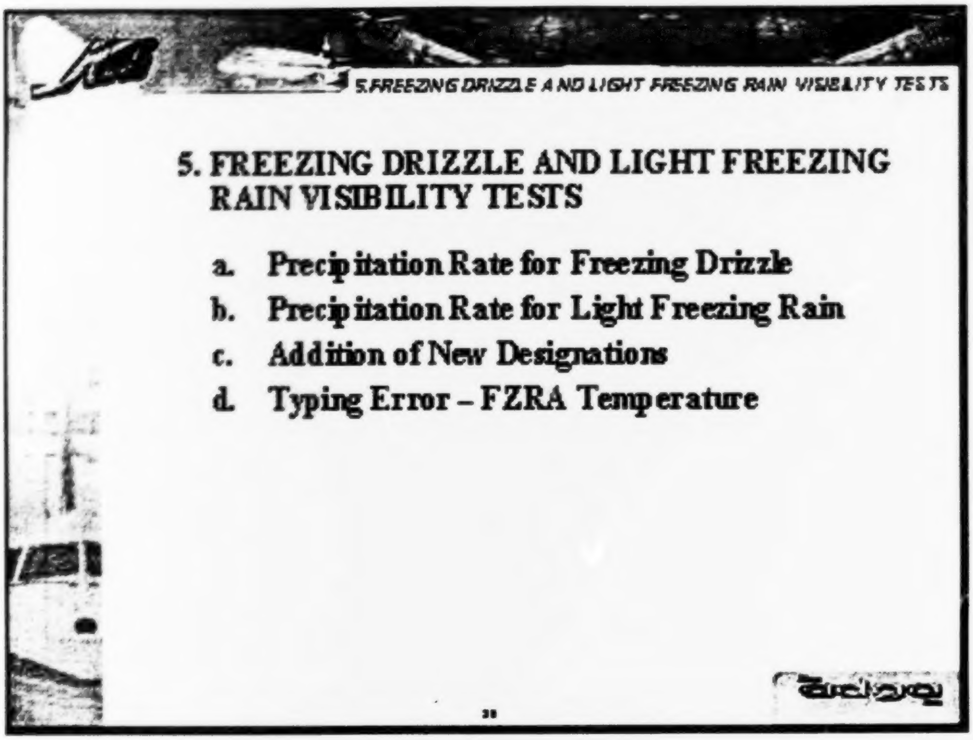
4. SNOW VISIBILITY TESTS FOR REMOTE GIDS

EXCERPT modified

Table 12 proposed change states the following:

Table 12 Snow Test Conditions

Test Condition	SN-B	SN-D	SN-E	SN-V (Visibility test for remote GIDS)
Air temperature, °C	[illegible]	-10°C ± 2	-10 ± 2	Any
Icing intensity, g/dm²/h	25 ± 5.0	25 ± 5.0	10 ± 1.5	> 25 g/dm²/h



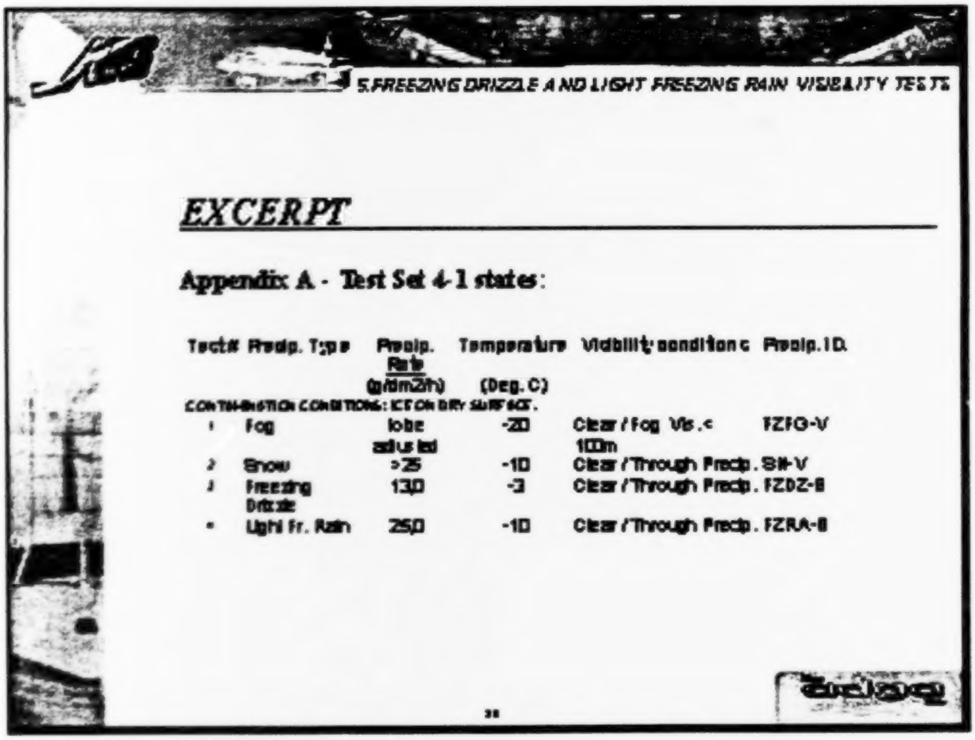
5. FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

a. Precipitation Rate for Freezing Drizzle

b. Precipitation Rate for Light Freezing Rain

c. Addition of New Designations

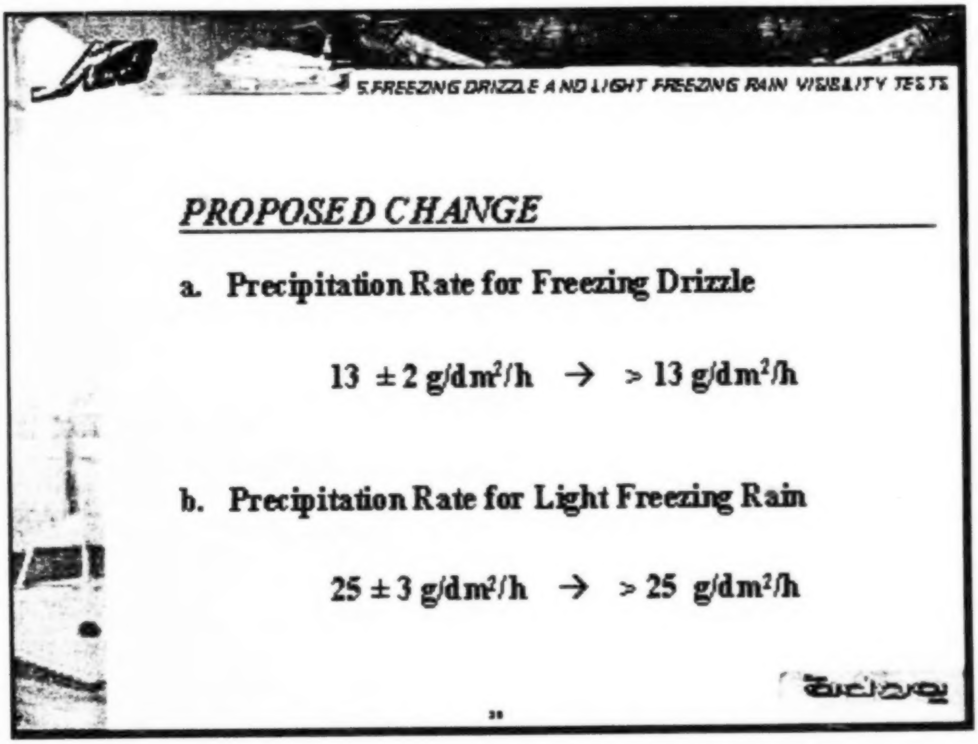
d. Typing Error – FZRA Temperature



EXCERPT

Appendix A - Test Set 4-1 states:

Test#	Precip. Type	Precip. Rate (g/dm2/h)	Temperature (Deg. C)	Visibility condition	Precip. ID.
CONTAMINATION CONDITIONS: ICE ON DRY SURFACE.					
1	Fog	to be adjusted	-20	Clear / Fog Vis.< 100m	FZFG-V
2	Snow	>25	-10	Clear / Through Precip.	SN-V
3	Freezing Drizzle	13.0	-3	Clear / Through Precip.	FZDZ-B
4	Light Fr. Rain	25.0	-10	Clear / Through Precip.	FZRA-B



5.FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

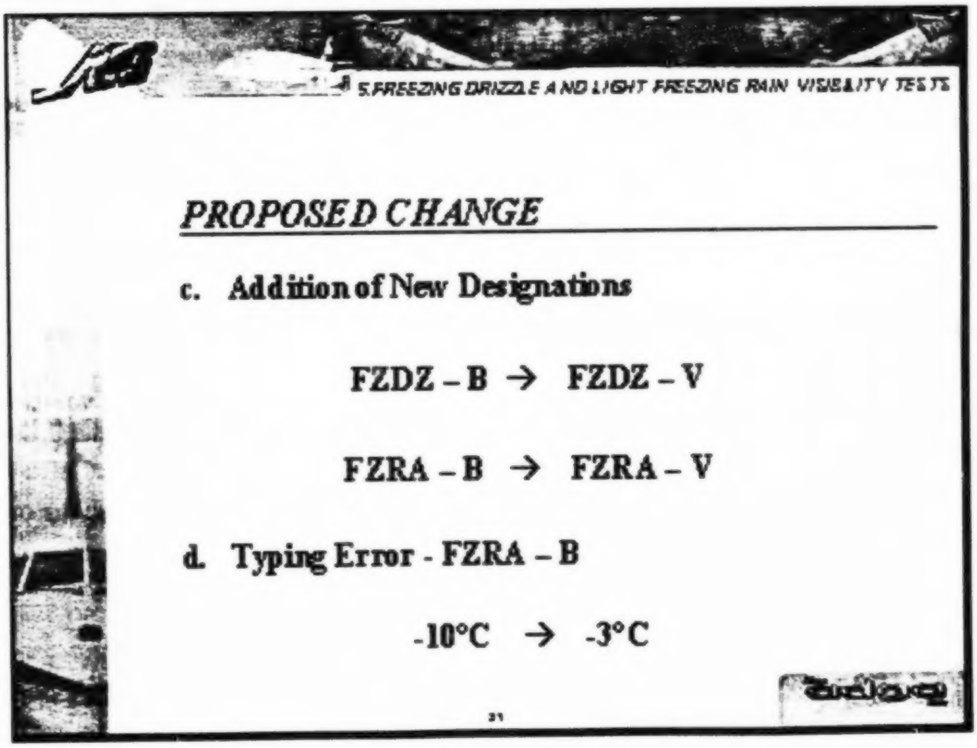
PROPOSED CHANGE

a. Precipitation Rate for Freezing Drizzle

13 ± 2 g/dm²/h → > 13 g/dm²/h

b. Precipitation Rate for Light Freezing Rain

25 ± 3 g/dm²/h → > 25 g/dm²/h



5.FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

PROPOSED CHANGE

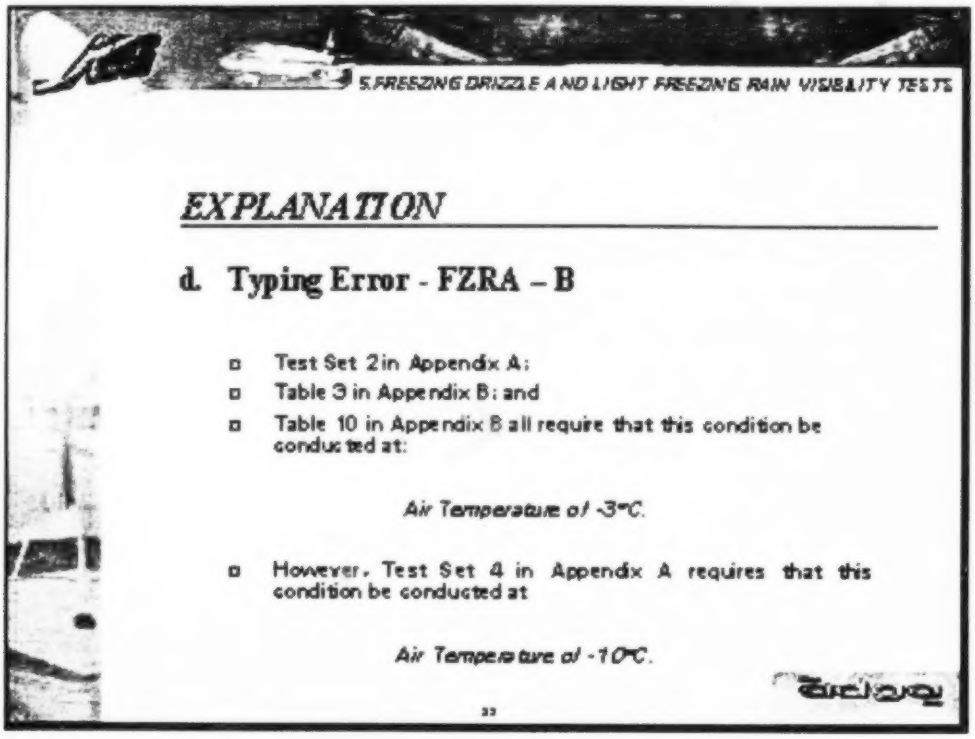
c. Addition of New Designations

FZDZ – B → FZDZ – V

FZRA – B → FZRA – V

d. Typing Error - FZRA – B

-10°C → -3°C



5.FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

EXPLANATION

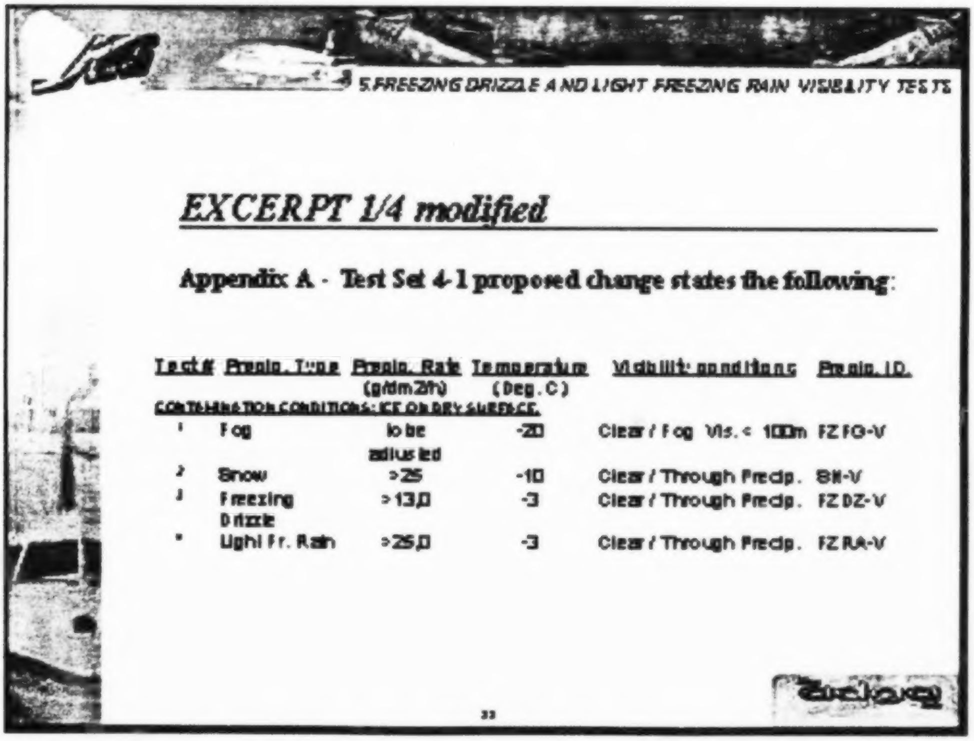
d. Typing Error - FZRA – B

- Test Set 2 in Appendix A;
- Table 3 in Appendix B; and
- Table 10 in Appendix B all require that this condition be conducted at:

Air Temperature of -3°C.

- However, Test Set 4 in Appendix A requires that this condition be conducted at

Air Temperature of -10°C.

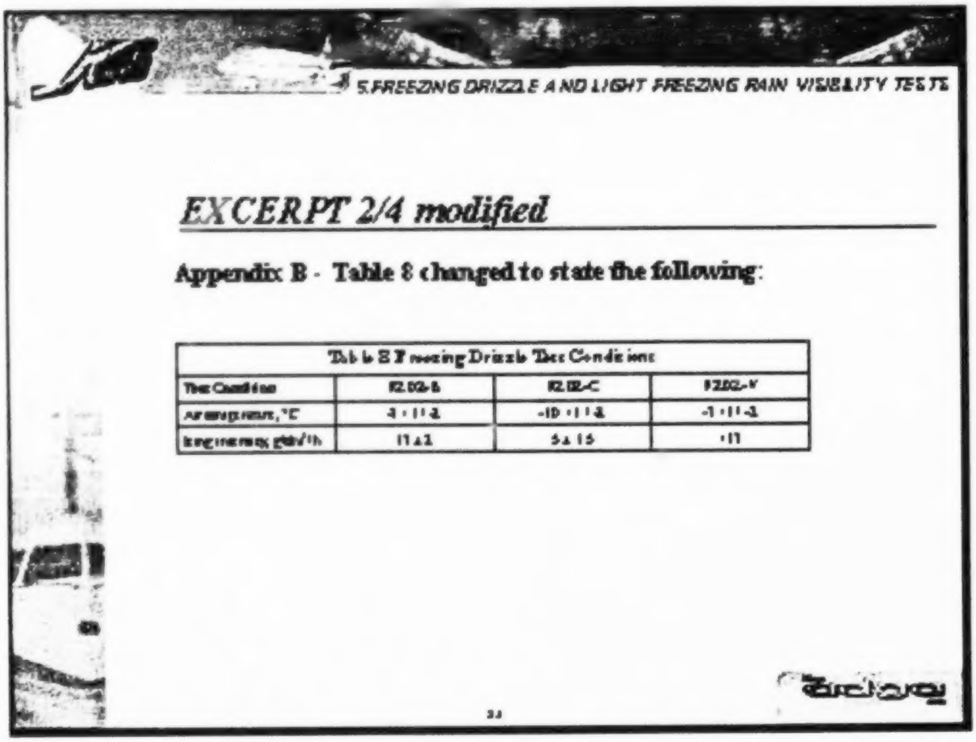


5.FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

EXCERPT 1/4 modified

Appendix A - Test Set 4-1 proposed change states the following:

Test #	Precip. Type	Precip. Rate (g/dm2/h)	Temperature (Deg. C)	Visibility conditions	Precip. ID.
CONTAMINATION CONDITIONS: ICE OR DRY SURFACE.					
1	Fog	to be adjusted	-20	Clear / Fog Vis. < 100m	FZFG-V
2	Snow	>25	-10	Clear / Through Precip.	SN-V
3	Freezing Drizzle	>13.0	-3	Clear / Through Precip.	FZDZ-V
4	Light Fr. Rain	>25.0	-3	Clear / Through Precip.	FZRA-V

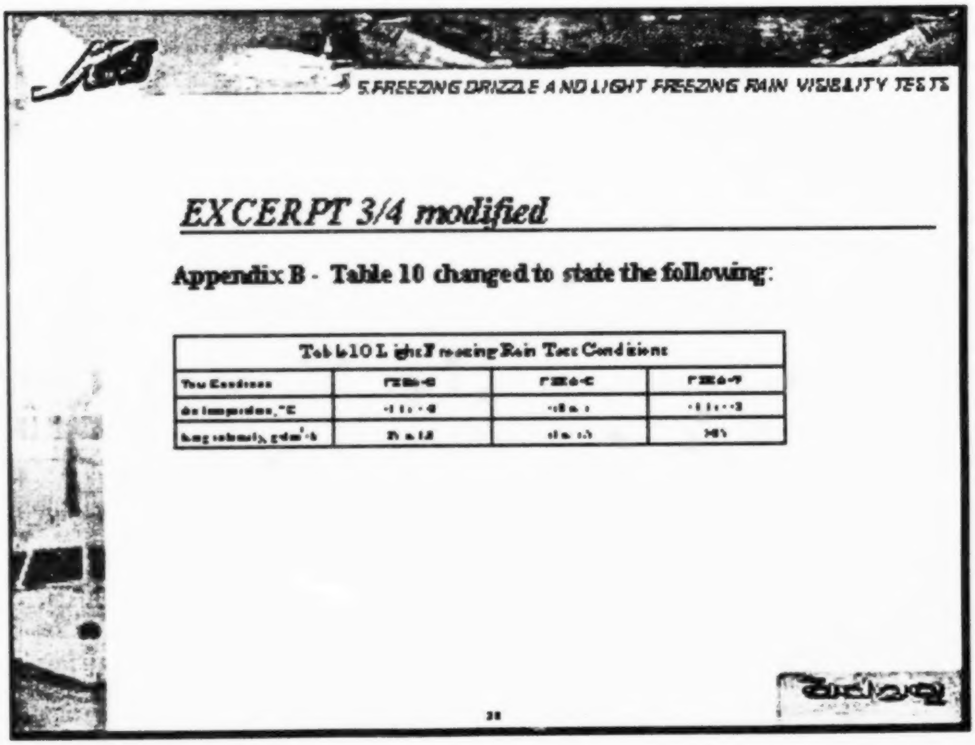


5.FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

EXCERPT 2/4 modified

Appendix B - Table 8 changed to state the following:

Table 8 Freezing Drizzle Test Conditions			
Test Condition	FZDZ-B	FZDZ-C	FZDZ-V
Air temperature, °C	[illegible]	[illegible]	[illegible]
Icing intensity, g/dm²/h	11 ± 2	5 ± 1.5	[illegible]

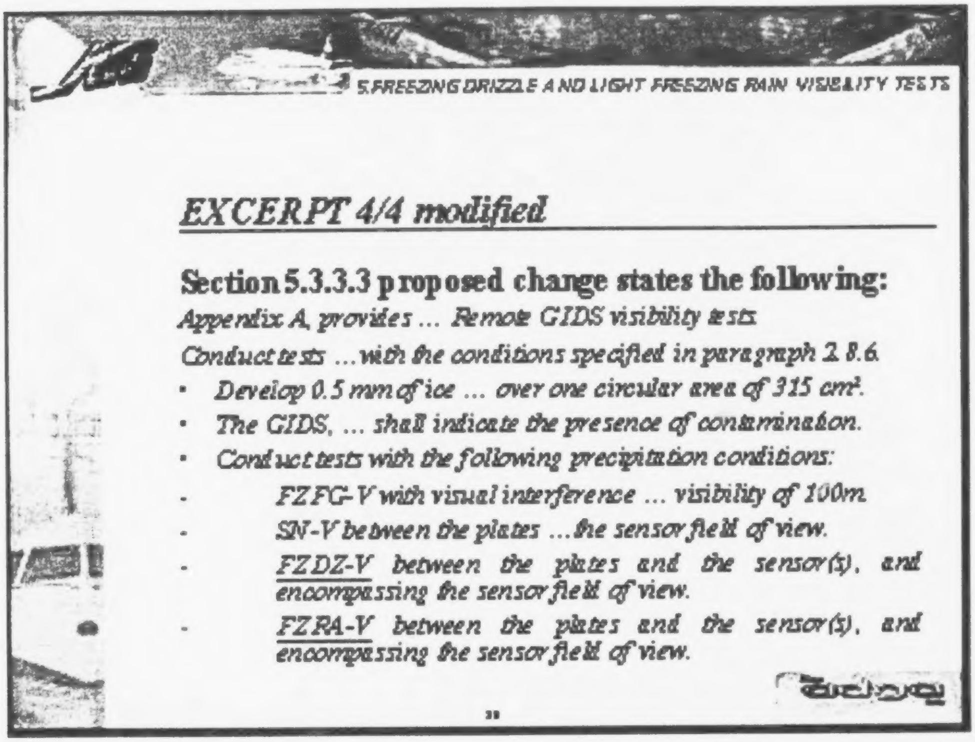


5.FREEZING DRIZZLE AND LIGHT FREEZING RAIN VISIBILITY TESTS

EXCERPT 3/4 modified

Appendix B - Table 10 changed to state the following:

Table 10 Light Freezing Rain Test Conditions			
Test Condition	[illegible]	[illegible]	[illegible]
Air temperature, °C	[illegible]	[illegible]	[illegible]
Icing intensity, g/dm²/h	[illegible]	[illegible]	[illegible]



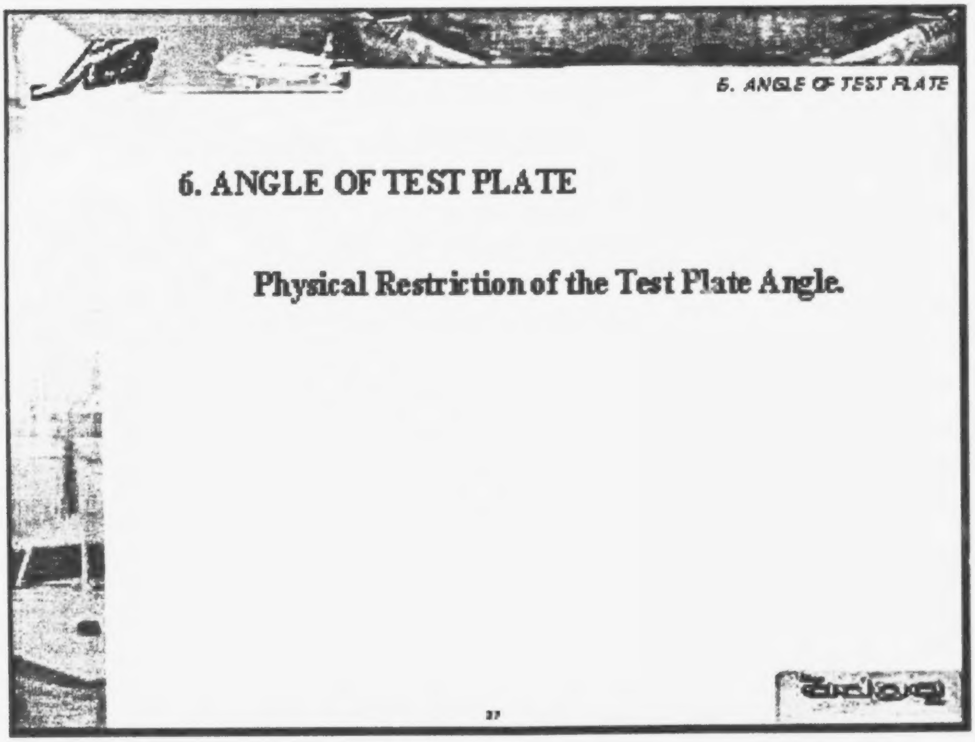
EXCERPT 4/4 modified

Section 5.3.3.3 proposed change states the following:

Appendix A, provides ... Remote GIDS visibility tests

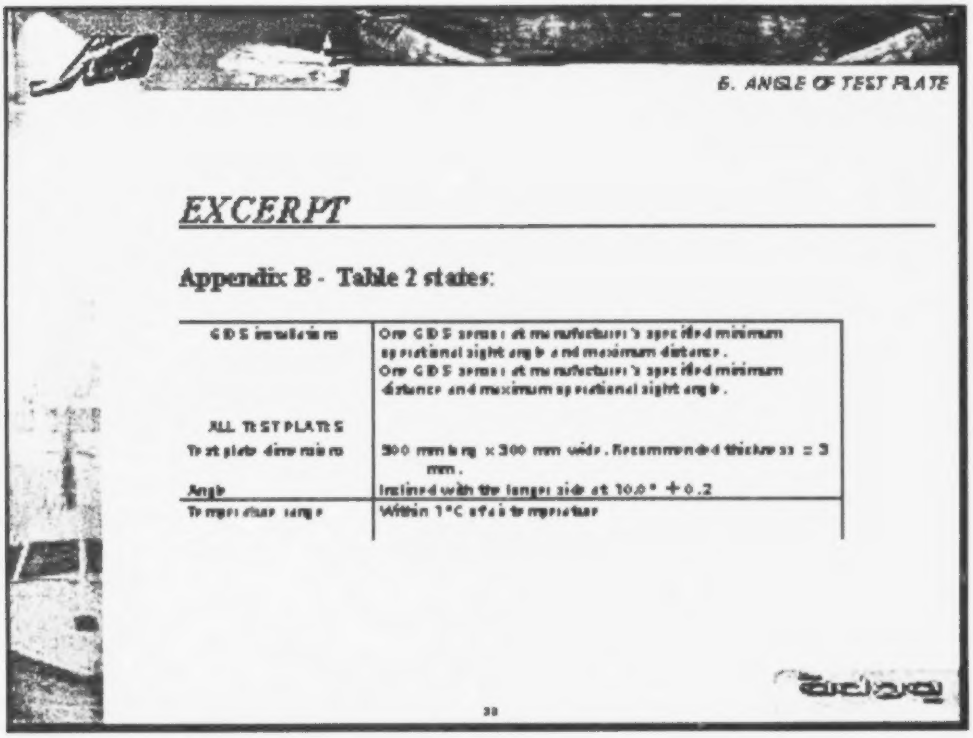
Conduct tests ...with the conditions specified in paragraph 2.8.6.

- *Develop 0.5 mm of ice ... over one circular area of 315 cm².*
- *The GIDS, ... shall indicate the presence of contamination.*
- *Conduct tests with the following precipitation conditions:*
    - *FZFG-V with visual interference ... visibility of 100m.*
    - *SN-V between the plates ...the sensor field of view.*
    - *FZDZ-V between the plates and the sensor(s), and encompassing the sensor field of view.*
    - *FZRA-V between the plates and the sensor(s), and encompassing the sensor field of view.*



6. ANGLE OF TEST PLATE

Physical Restriction of the Test Plate Angle.

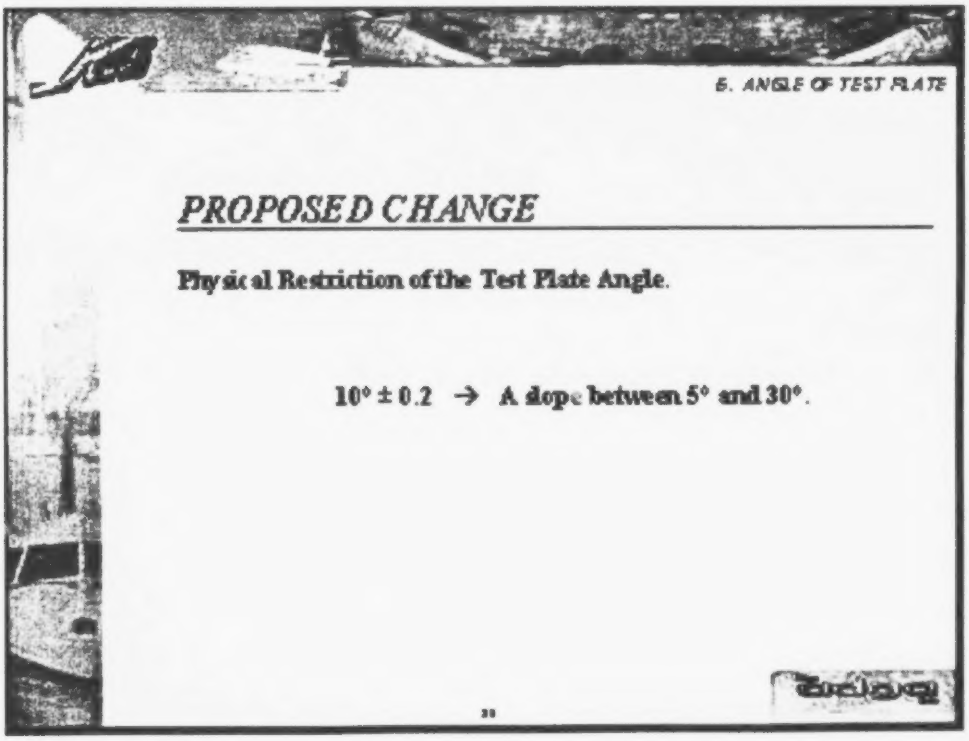


6. ANGLE OF TEST PLATE

EXCERPT

Appendix B - Table 2 states:

GDS installations	One GDS sensor at manufacturer's specified minimum operational sight angle and maximum distance. One GDS sensor at manufacturer's specified minimum distance and maximum operational sight angle.
ALL TEST PLATES	
Test plate dimensions	300 mm long × 300 mm wide. Recommended thickness = 3 mm.
Angle	Inclined with the longer side at 10.0° + 0.2
Temperature range	Within 1°C of air temperature

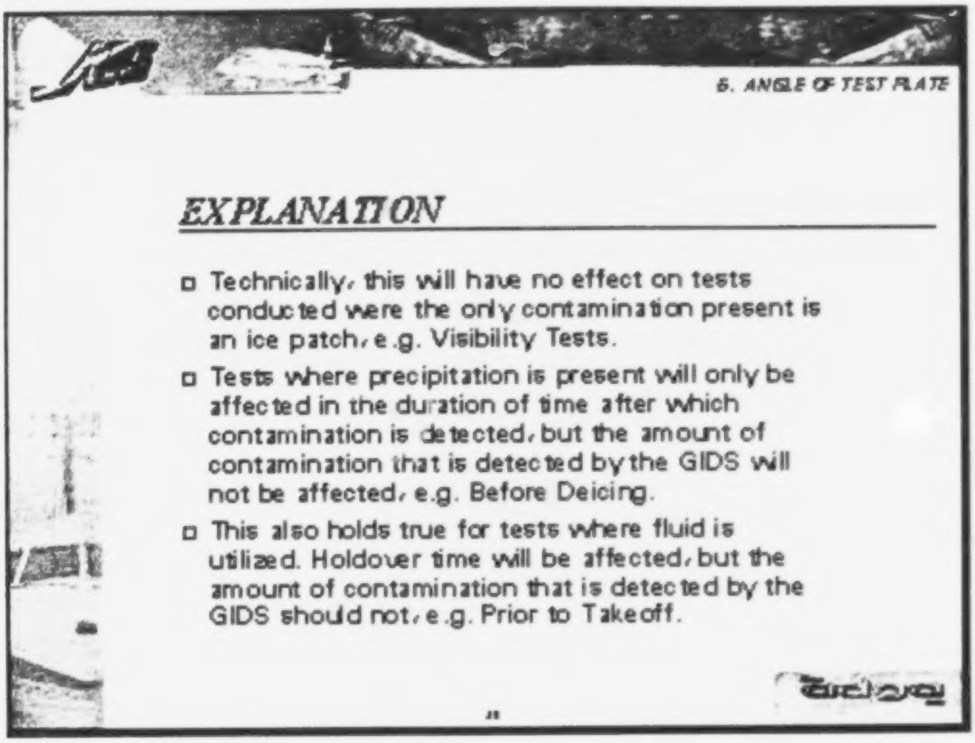


6. ANGLE OF TEST PLATE

PROPOSED CHANGE

Physical Restriction of the Test Plate Angle.

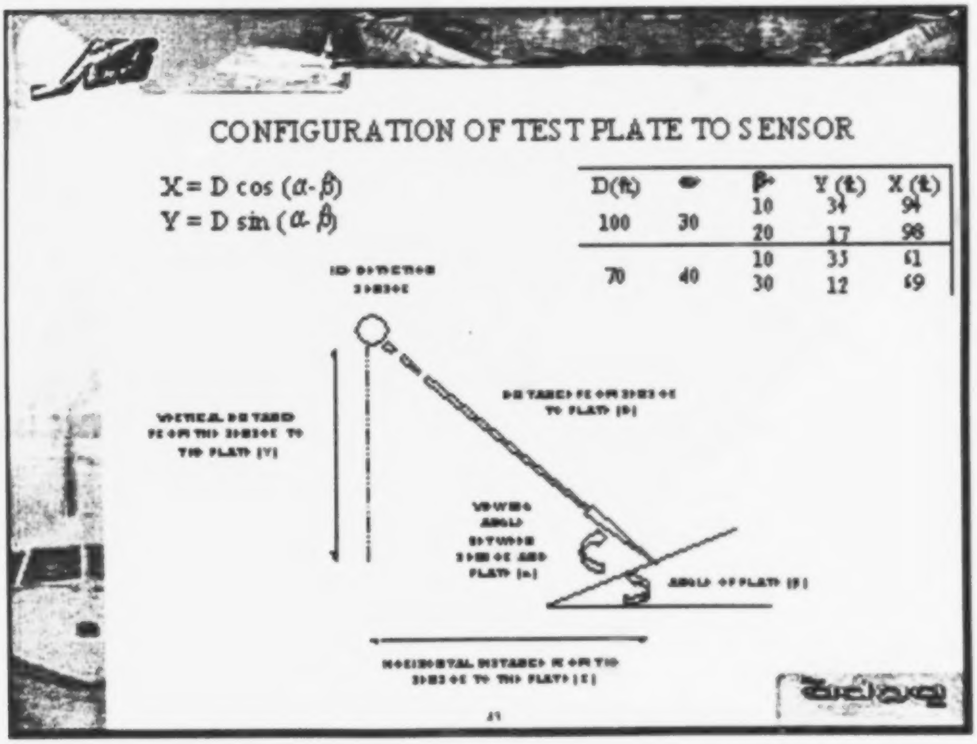
10° ± 0.2 → A slope between 5° and 30°.



6. ANGLE OF TEST PLATE

EXPLANATION

- Technically, this will have no effect on tests conducted were the only contamination present is an ice patch, e.g. Visibility Tests.
- Tests where precipitation is present will only be affected in the duration of time after which contamination is detected, but the amount of contamination that is detected by the GIDS will not be affected, e.g. Before Deicing.
- This also holds true for tests where fluid is utilized. Holdover time will be affected, but the amount of contamination that is detected by the GIDS should not, e.g. Prior to Takeoff.



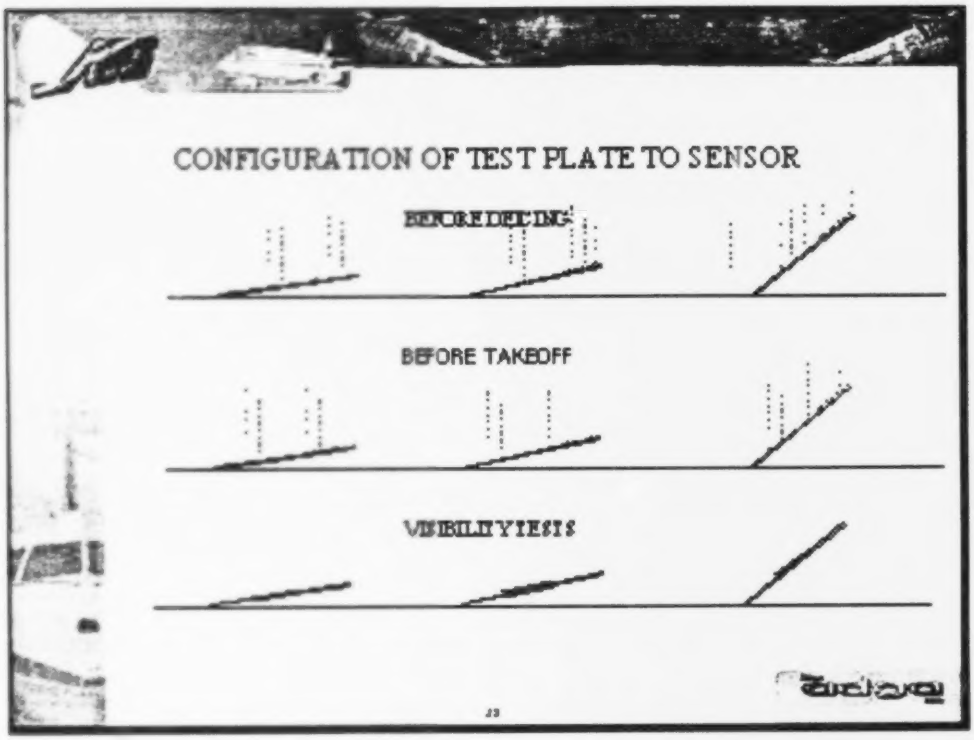
CONFIGURATION OF TEST PLATE TO SENSOR

$X = D \cos(\alpha - \beta)$

$Y = D \sin(\alpha - \beta)$

D(ft)	α	β	Y (ft)	X (ft)
100	30	10	34	94
		20	17	98
70	40	10	33	61
		30	12	69

ICE DETECTION SENSOR
DISTANCE FROM SENSOR TO PLATE (D)
VERTICAL DISTANCE FROM THE SENSOR TO THE PLATE (Y)
VIEWING ANGLE BETWEEN SENSOR AND PLATE (α)
ANGLE OF PLATE (β)
HORIZONTAL DISTANCE FROM THE SENSOR TO THE PLATE (X)

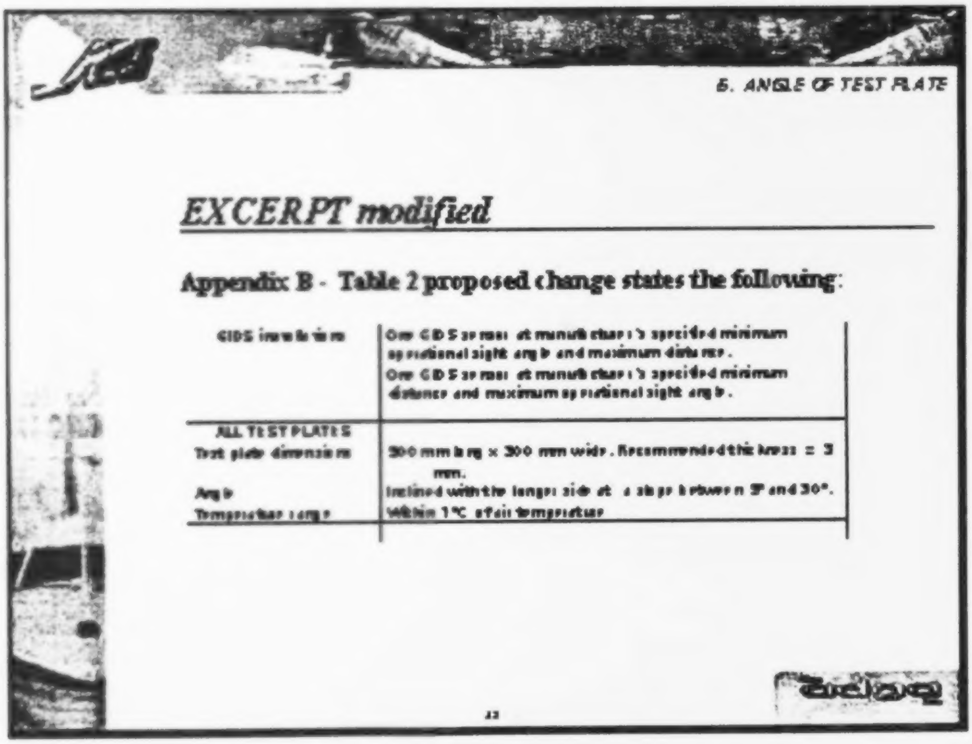


CONFIGURATION OF TEST PLATE TO SENSOR

BEFORE DEICING

BEFORE TAKEOFF

VISIBILITY TESTS

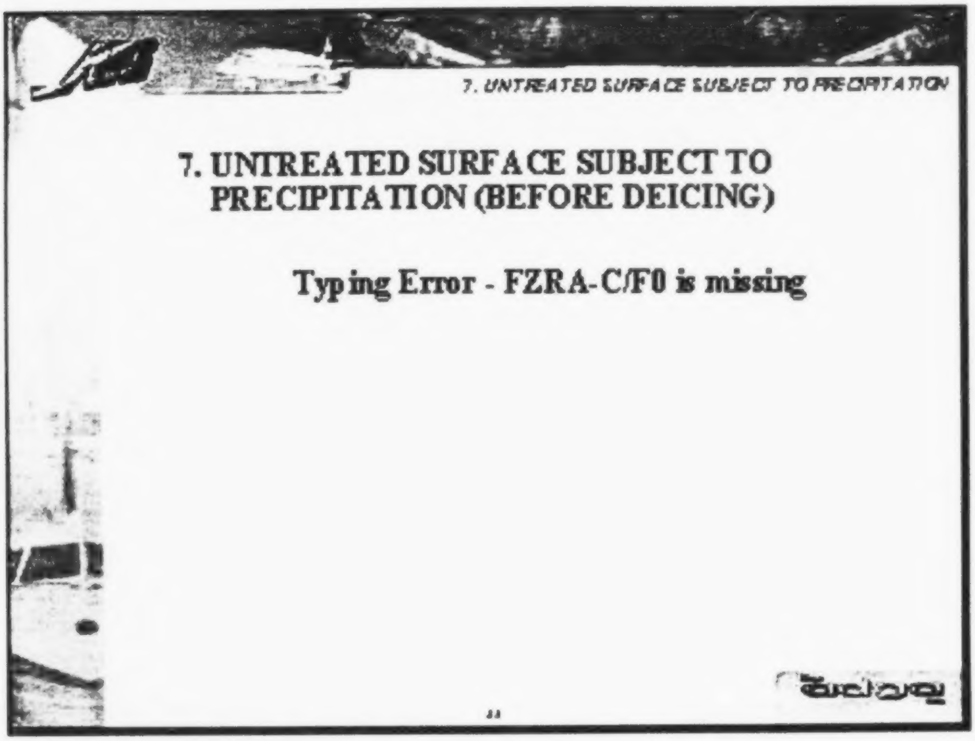


6. ANGLE OF TEST PLATE

EXCERPT modified

Appendix B - Table 2 proposed change states the following:

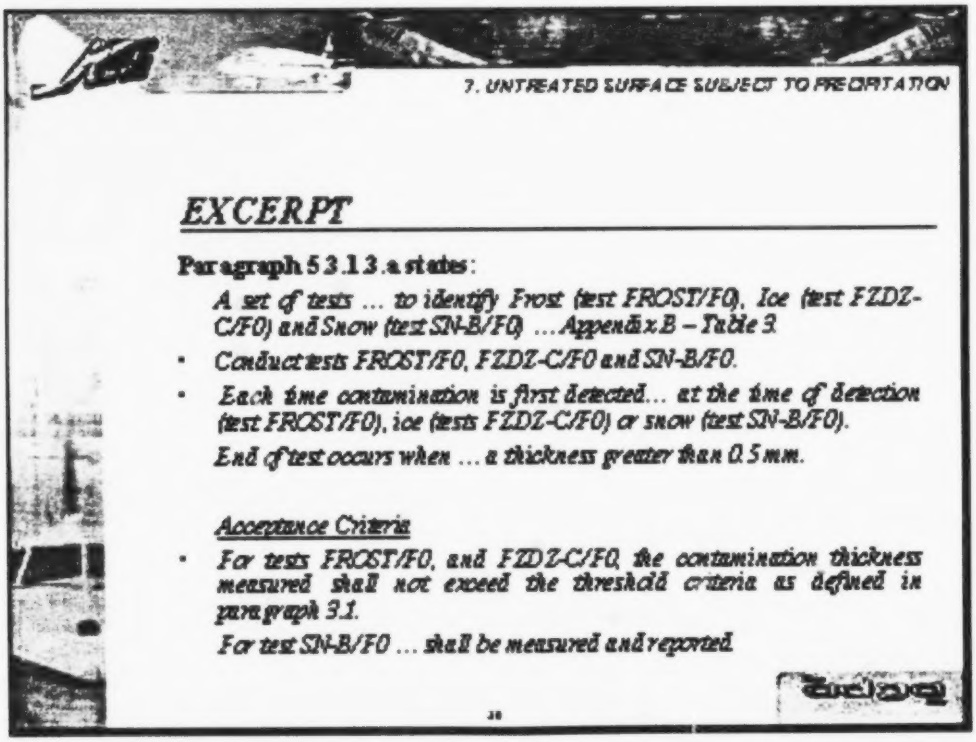
GIDS installation	One GIDS sensor at manufacturer's specified minimum operational sight angle and maximum distance. One GIDS sensor at manufacturer's specified minimum distance and maximum operational sight angle.
ALL TEST PLATES	
Test plate dimensions	500 mm long × 300 mm wide. Recommended thickness = 3 mm.
Angle	Inclined with the longer side at a slope between 5° and 30°.
Temperature range	Within 1°C of air temperature



7. UNTREATED SURFACE SUBJECT TO PRECIPITATION

7. UNTREATED SURFACE SUBJECT TO PRECIPITATION (BEFORE DEICING)

Typing Error - FZRA-C/F0 is missing



7. UNTREATED SURFACE SUBJECT TO PRECIPITATION

EXCERPT

Paragraph 5.3.1.3.a states:

A set of tests … to identify Frost (test FROST/F0), Ice (test FZDZ-C/F0) and Snow (test SN-B/F0) … Appendix B – Table 3.

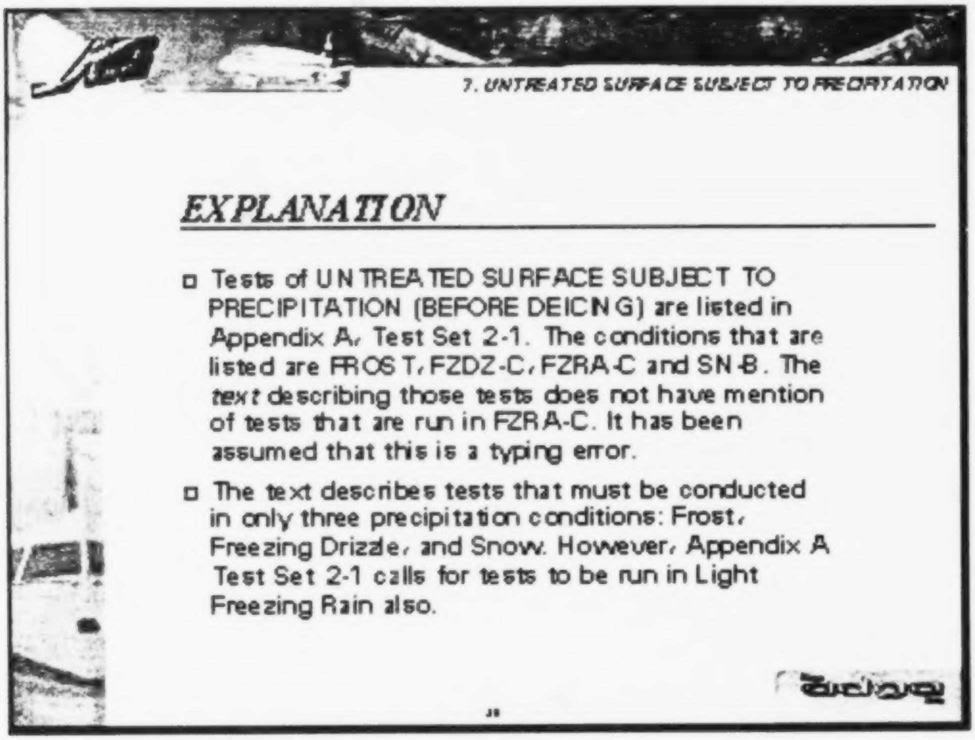
- *Conduct tests FROST/F0, FZDZ-C/F0 and SN-B/F0.*
- *Each time contamination is first detected… at the time of detection (test FROST/F0), ice (tests FZDZ-C/F0) or snow (test SN-B/F0).*

End of test occurs when … a thickness greater than 0.5 mm.

Acceptance Criteria

- *For tests FROST/F0, and FZDZ-C/F0, the contamination thickness measured shall not exceed the threshold criteria as defined in paragraph 3.1.*

For test SN-B/F0 … shall be measured and reported.



7. UNTREATED SURFACE SUBJECT TO PRECIPITATION

EXPLANATION

- ☐ Tests of UNTREATED SURFACE SUBJECT TO PRECIPITATION (BEFORE DEICING) are listed in Appendix A, Test Set 2-1. The conditions that are listed are FROST, FZDZ-C, FZRA-C and SN-B. The *text* describing those tests does not have mention of tests that are run in FZRA-C. It has been assumed that this is a typing error.
- ☐ The text describes tests that must be conducted in only three precipitation conditions: Frost, Freezing Drizzle, and Snow. However, Appendix A Test Set 2-1 calls for tests to be run in Light Freezing Rain also.

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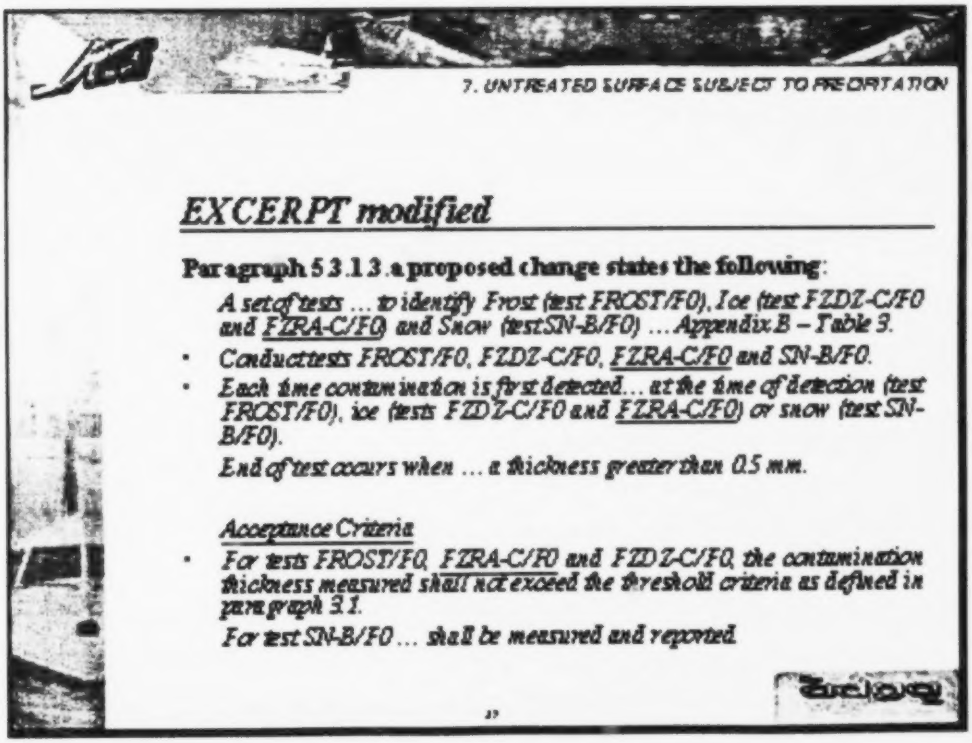

7. UNTREATED SURFACE SUBJECT TO PRECIPITATION

EXCERPT modified

Paragraph 5.3.1.3.a proposed change states the following:

A set of tests ... to identify Frost (test FROST/F0), Ice (test FZDZ-C/F0 and FZRA-C/F0) and Snow (test SN-B/F0) ... Appendix B – Table 3.

- *Conduct tests FROST/F0, FZDZ-C/F0, FZRA-C/F0 and SN-B/F0.*
- *Each time contamination is first detected... at the time of detection (test FROST/F0), ice (tests FZDZ-C/F0 and FZRA-C/F0) or snow (test SN-B/F0).*

End of test occurs when ... a thickness greater than 0.5 mm.

Acceptance Criteria

- *For tests FROST/F0, FZRA-C/F0 and FZDZ-C/F0, the contamination thickness measured shall not exceed the threshold criteria as defined in paragraph 3.1.*

For test SN-B/F0 ... shall be measured and reported.

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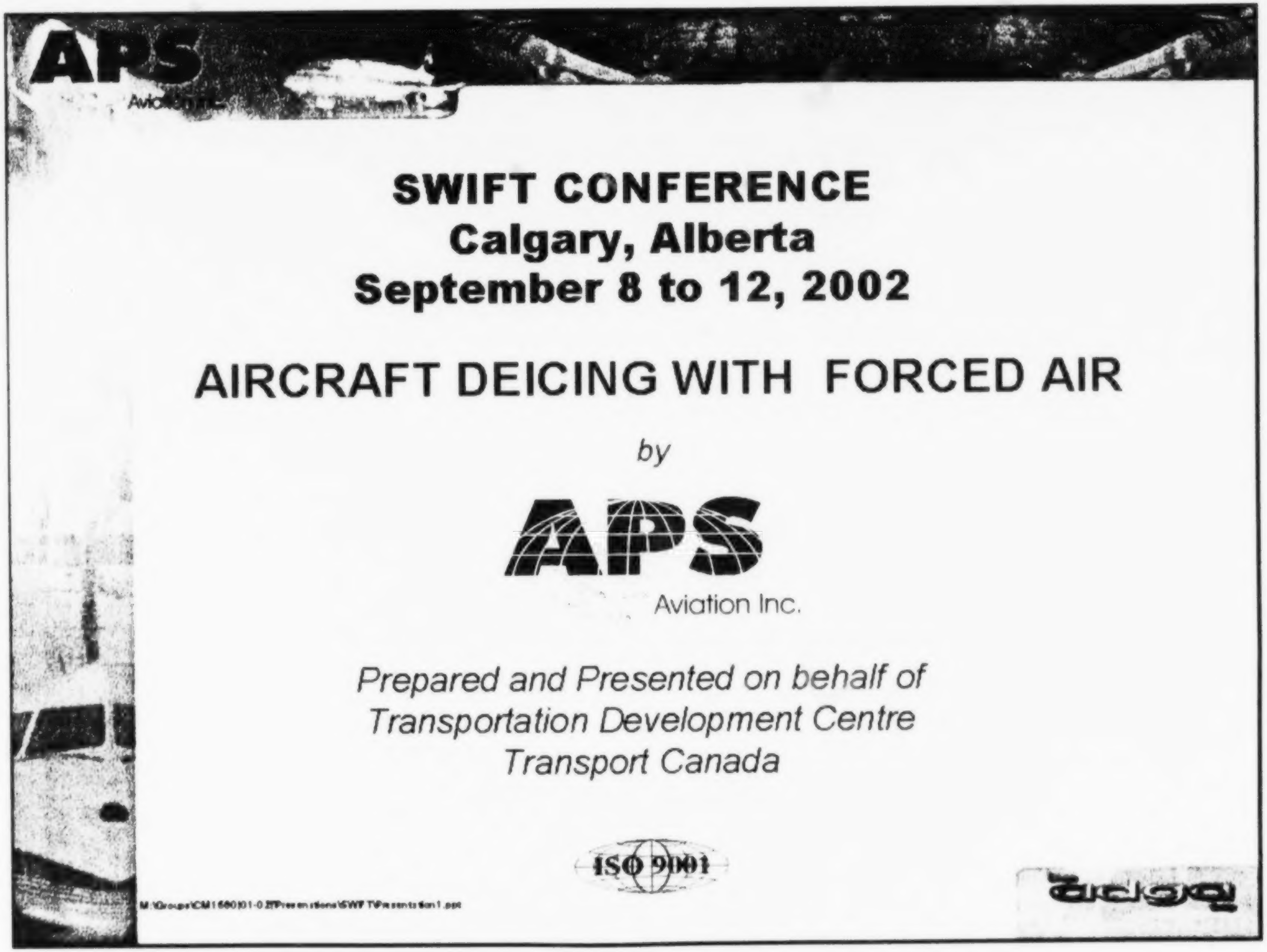
THE END



APS
Aviation Inc.

SWIFT CONFERENCE
Calgary, Alberta
September 8 to 12, 2002

AIRCRAFT DEICING WITH FORCED AIR

by

APS
Aviation Inc.

Prepared and Presented on behalf of
Transportation Development Centre
Transport Canada

ISO 9001

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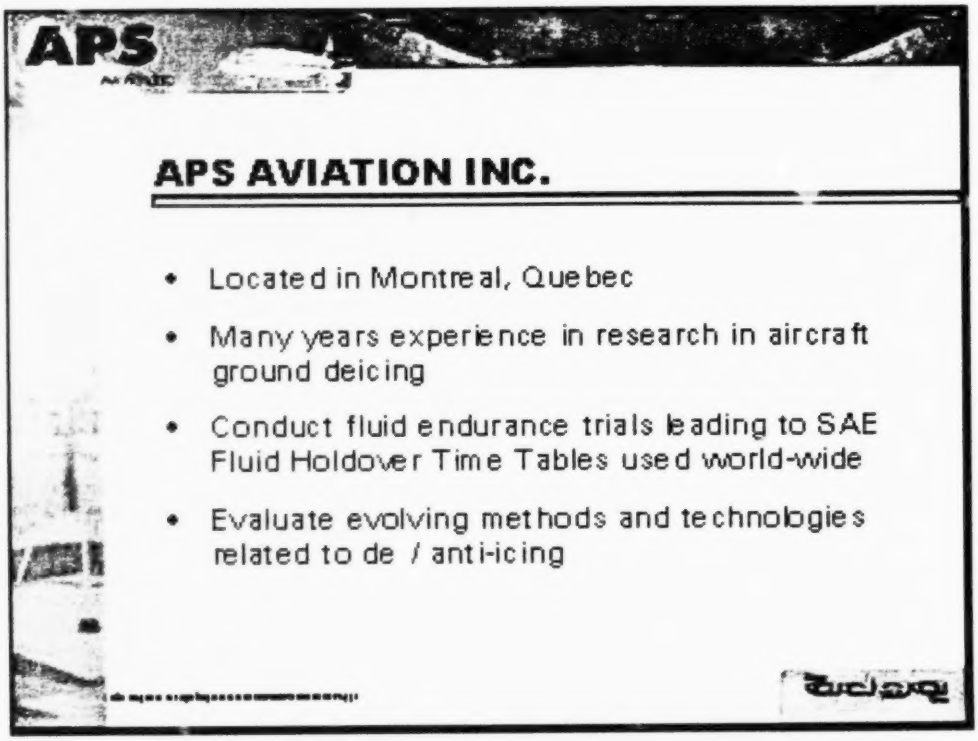
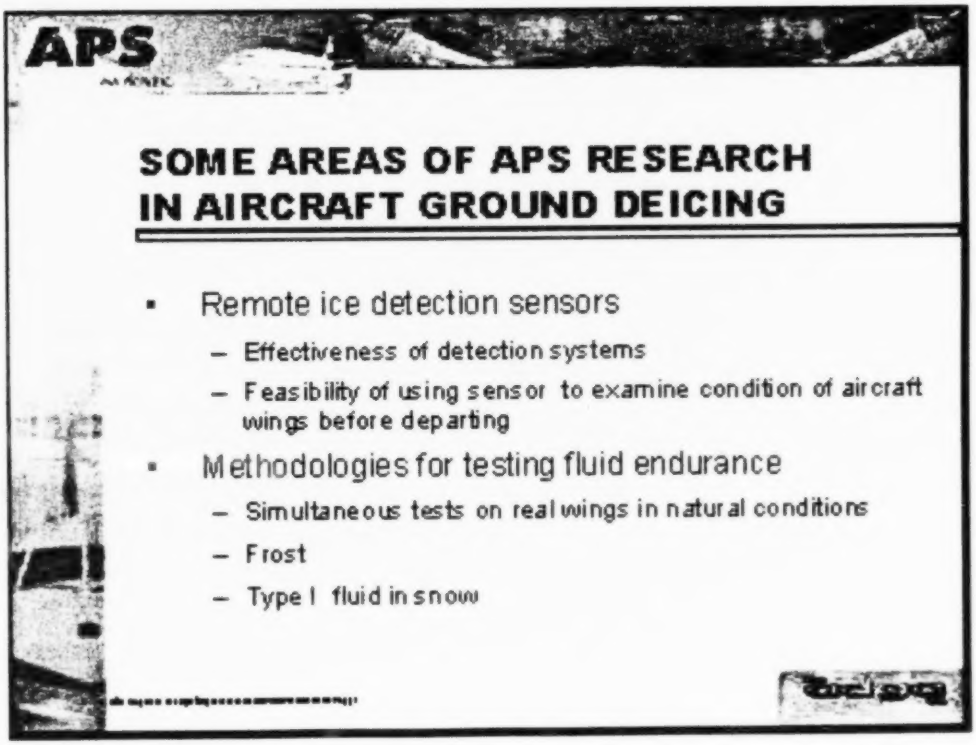


APS

APS AVIATION INC.

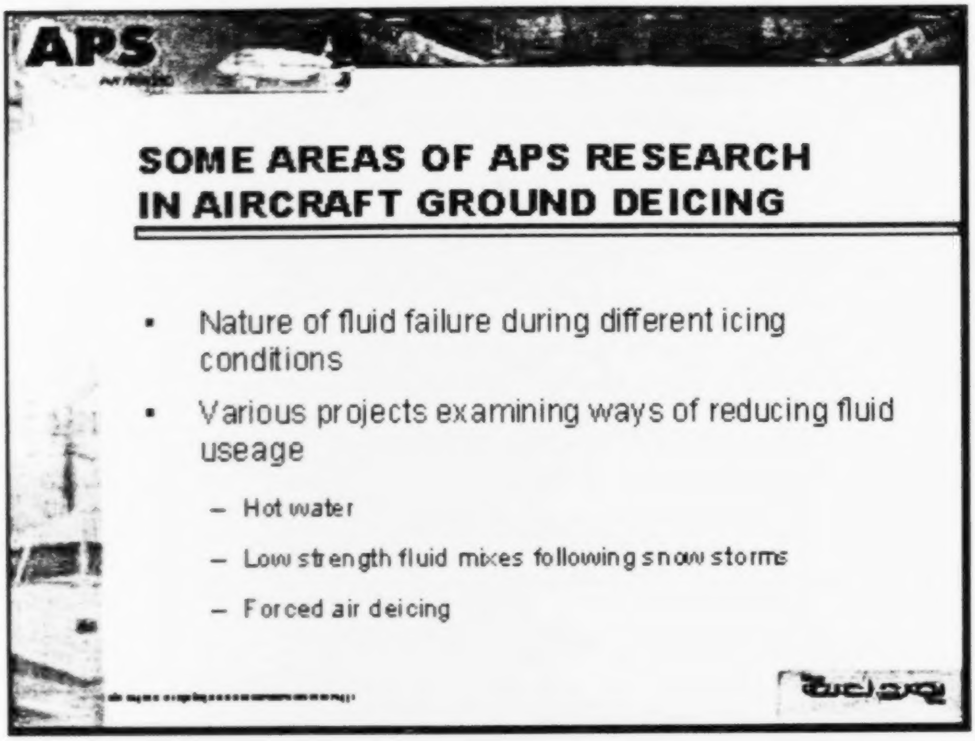
- Located in Montreal, Quebec
- Many years experience in research in aircraft ground deicing
- Conduct fluid endurance trials leading to SAE Fluid Holdover Time Tables used world-wide
- Evaluate evolving methods and technologies related to de / anti-icing



APS

SOME AREAS OF APS RESEARCH IN AIRCRAFT GROUND DEICING

- Remote ice detection sensors
  - Effectiveness of detection systems
  - Feasibility of using sensor to examine condition of aircraft wings before departing
- Methodologies for testing fluid endurance
  - Simultaneous tests on real wings in natural conditions
  - Frost
  - Type I fluid in snow



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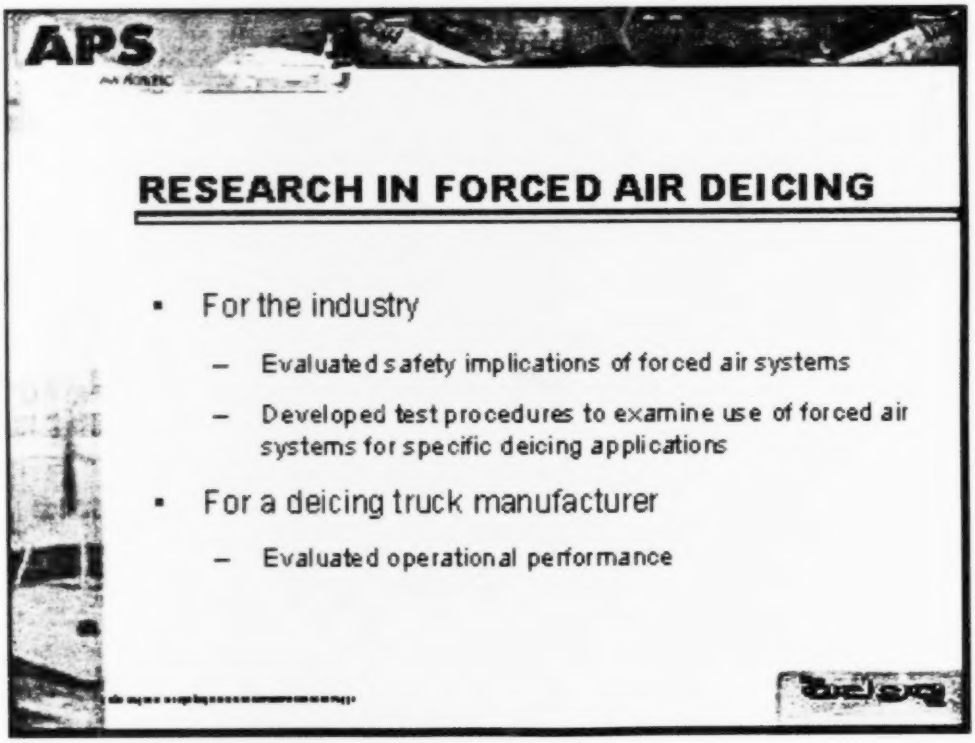
SOME AREAS OF APS RESEARCH IN AIRCRAFT GROUND DEICING

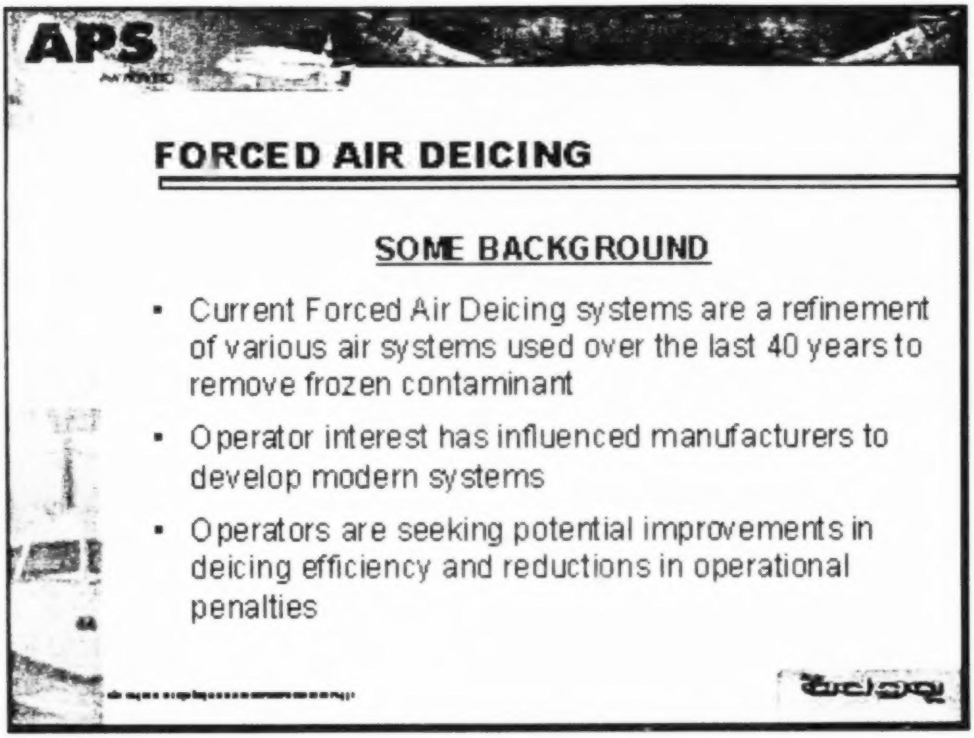
- Nature of fluid failure during different icing conditions
- Various projects examining ways of reducing fluid useage
  - Hot water
  - Low strength fluid mixes following snow storms
  - Forced air deicing



APS

RESEARCH IN FORCED AIR DEICING

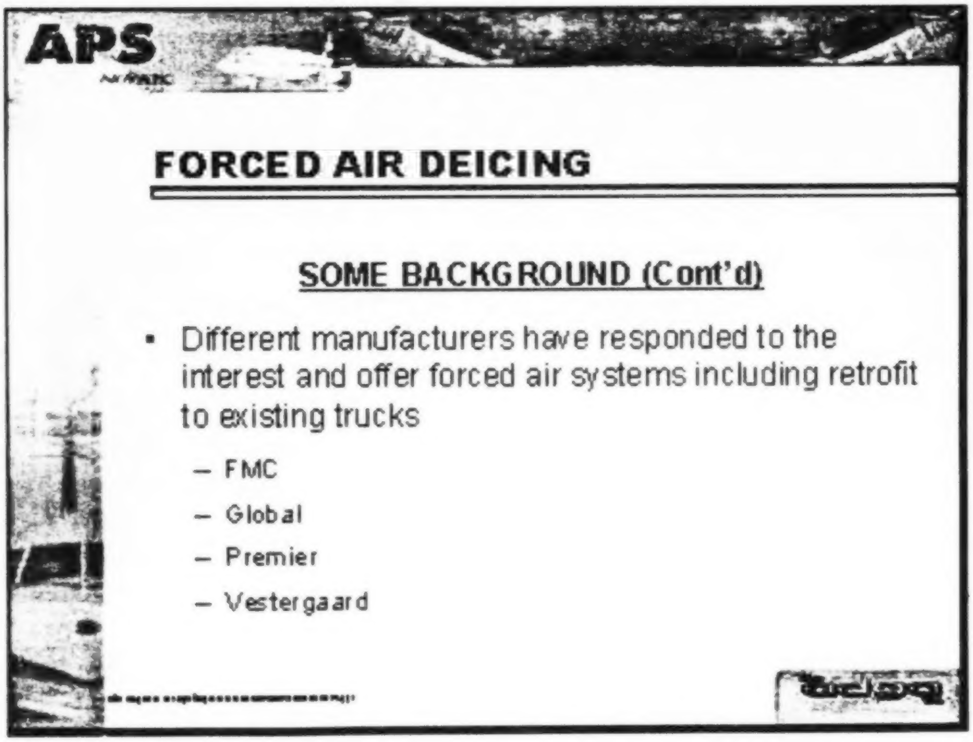
- For the industry
  - Evaluated safety implications of forced air systems
  - Developed test procedures to examine use of forced air systems for specific deicing applications
- For a deicing truck manufacturer
  - Evaluated operational performance



FORCED AIR DEICING

SOME BACKGROUND

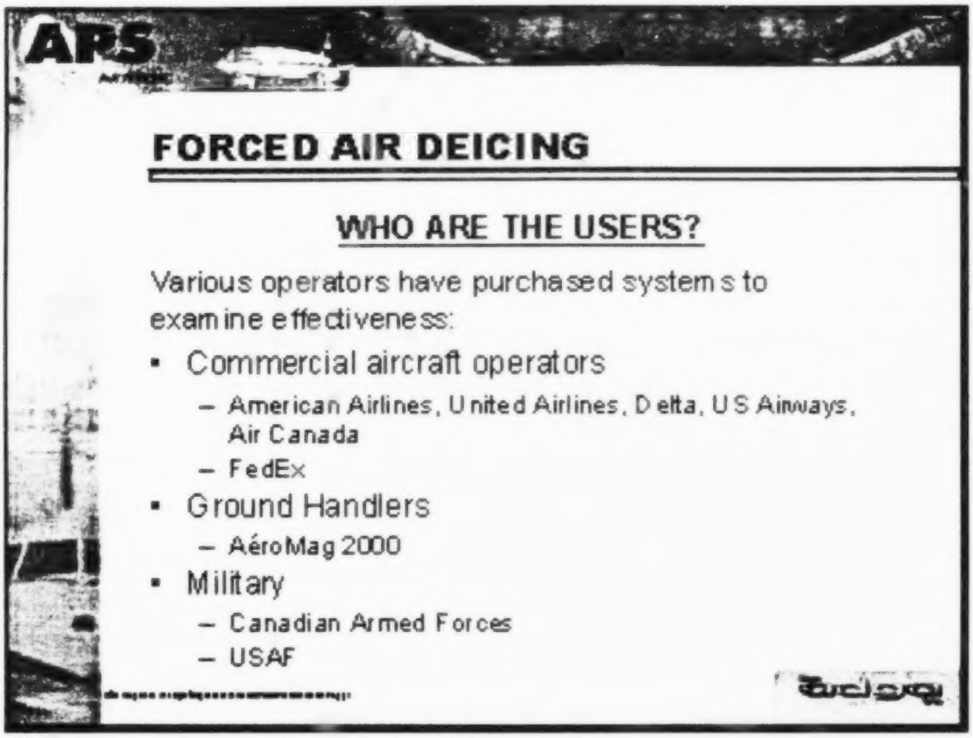
- Current Forced Air Deicing systems are a refinement of various air systems used over the last 40 years to remove frozen contaminant
- Operator interest has influenced manufacturers to develop modern systems
- Operators are seeking potential improvements in deicing efficiency and reductions in operational penalties



FORCED AIR DEICING

SOME BACKGROUND (Cont'd)

- Different manufacturers have responded to the interest and offer forced air systems including retrofit to existing trucks
  - FMC
  - Global
  - Premier
  - Vestergaard

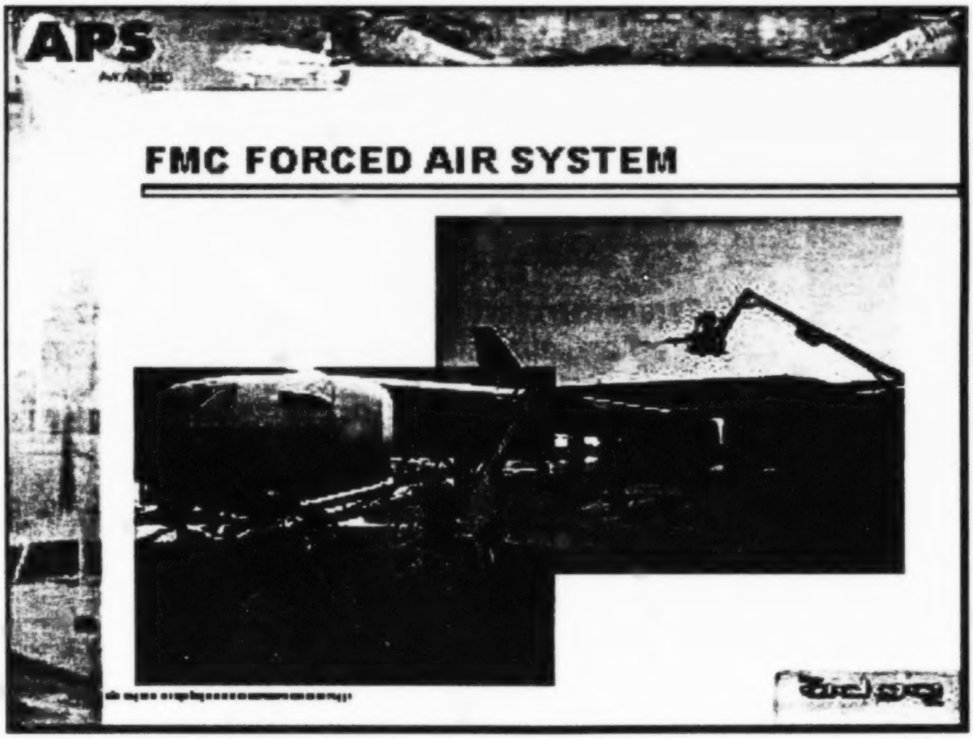


FORCED AIR DEICING

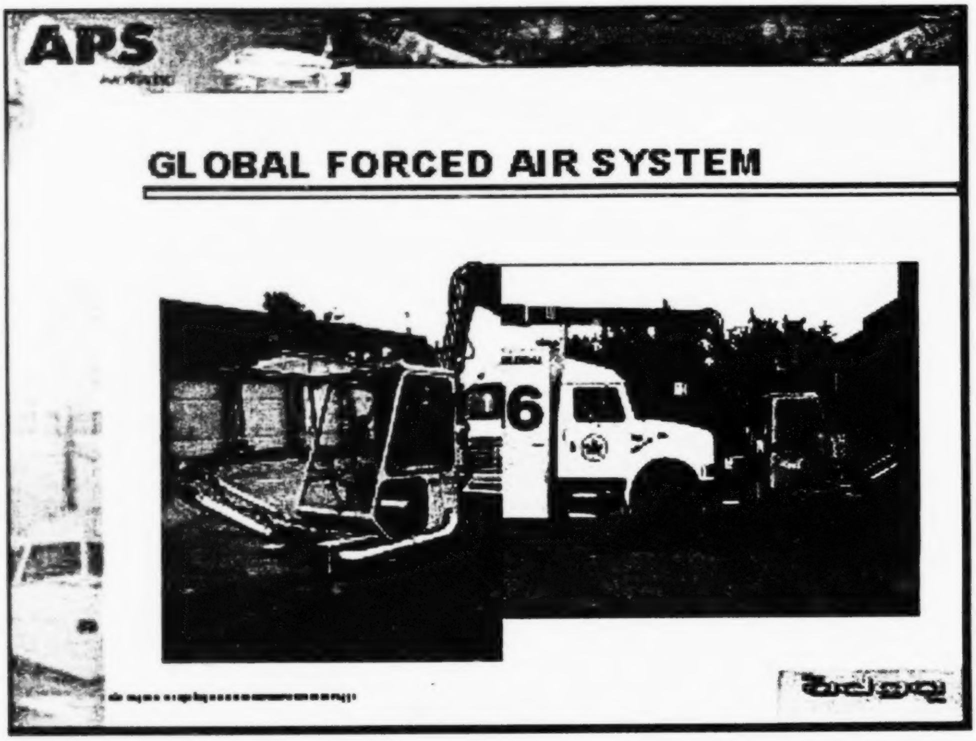
WHO ARE THE USERS?

Various operators have purchased systems to examine effectiveness:

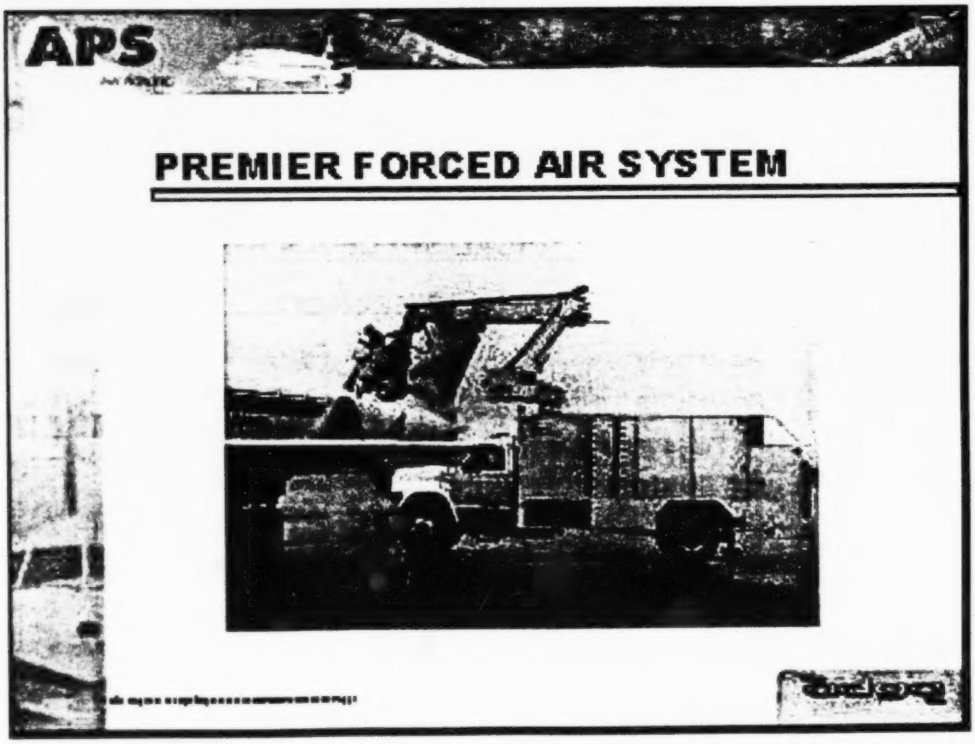
- Commercial aircraft operators
  - American Airlines, United Airlines, Delta, US Airways, Air Canada
  - FedEx
- Ground Handlers
  - AéroMag 2000
- Military
  - Canadian Armed Forces
  - USAF



FMC FORCED AIR SYSTEM

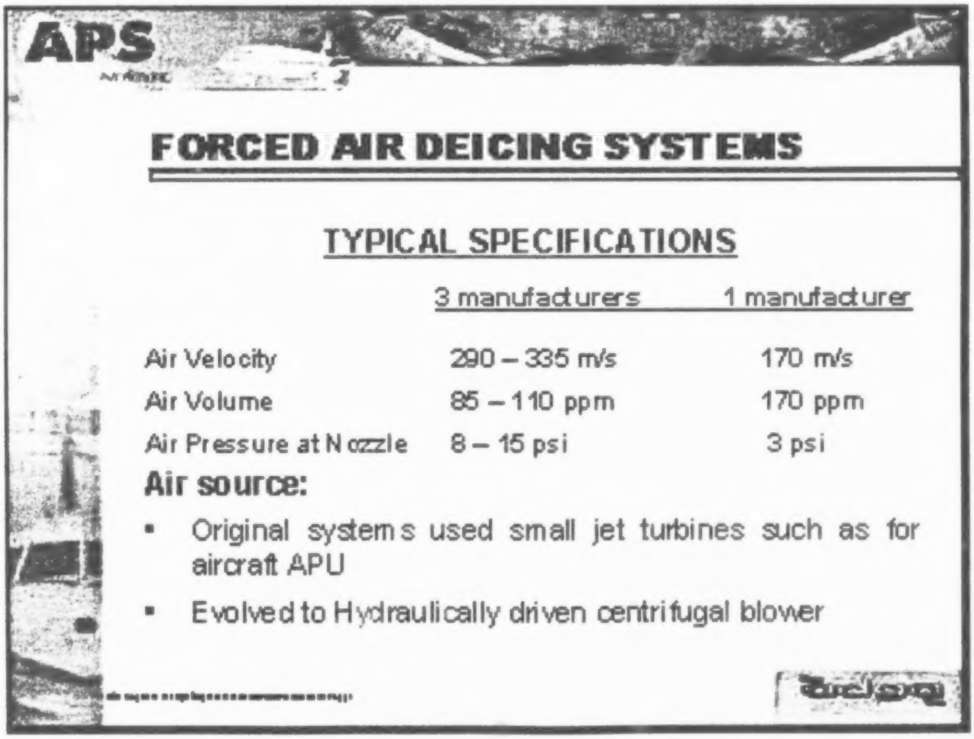


GLOBAL FORCED AIR SYSTEM



PREMIER FORCED AIR SYSTEM

VESTERGAARD FORCED AIR SYSTEM



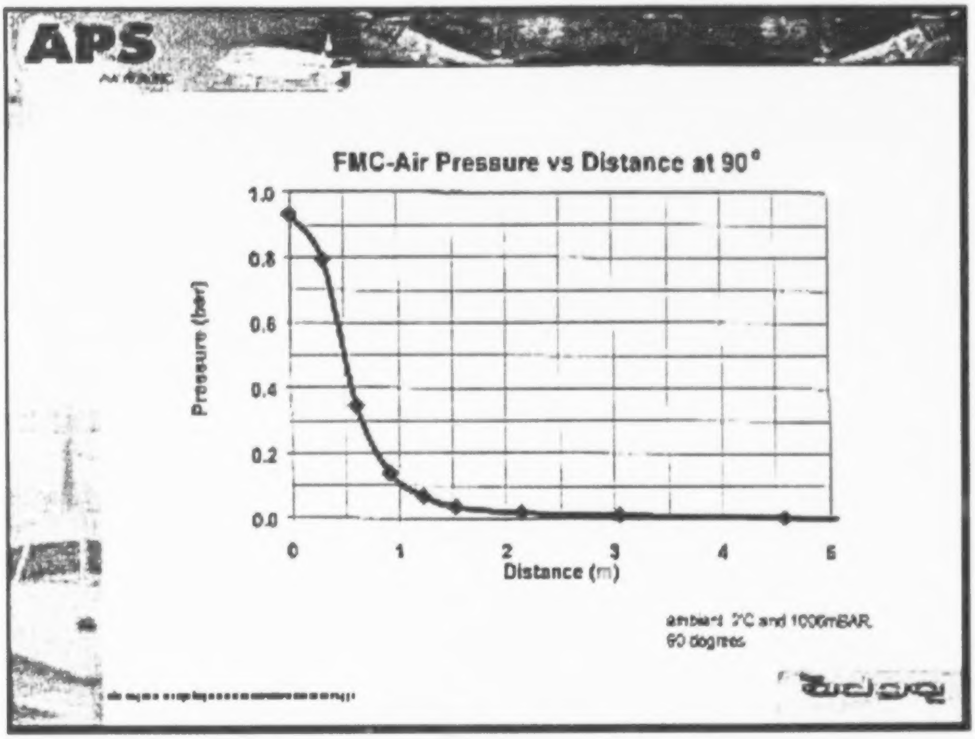
FORCED AIR DEICING SYSTEMS

TYPICAL SPECIFICATIONS

	3 manufacturers	1 manufacturer
Air Velocity	290 – 335 m/s	170 m/s
Air Volume	85 – 110 ppm	170 ppm
Air Pressure at Nozzle	8 – 15 psi	3 psi

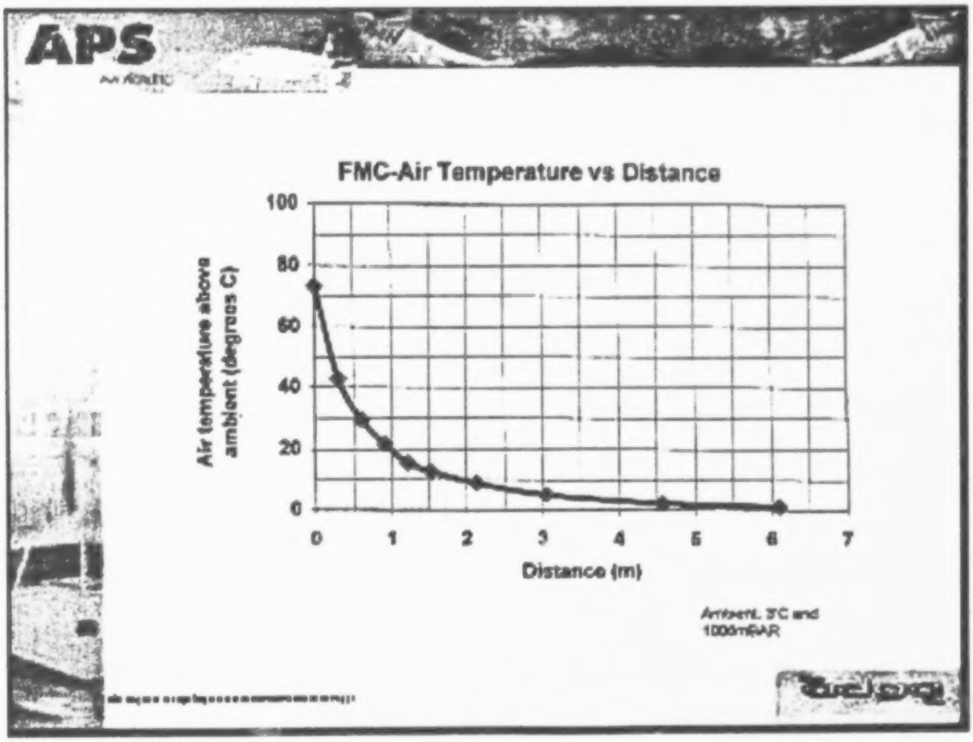
Air source:

- Original systems used small jet turbines such as for aircraft APU
- Evolved to Hydraulically driven centrifugal blower



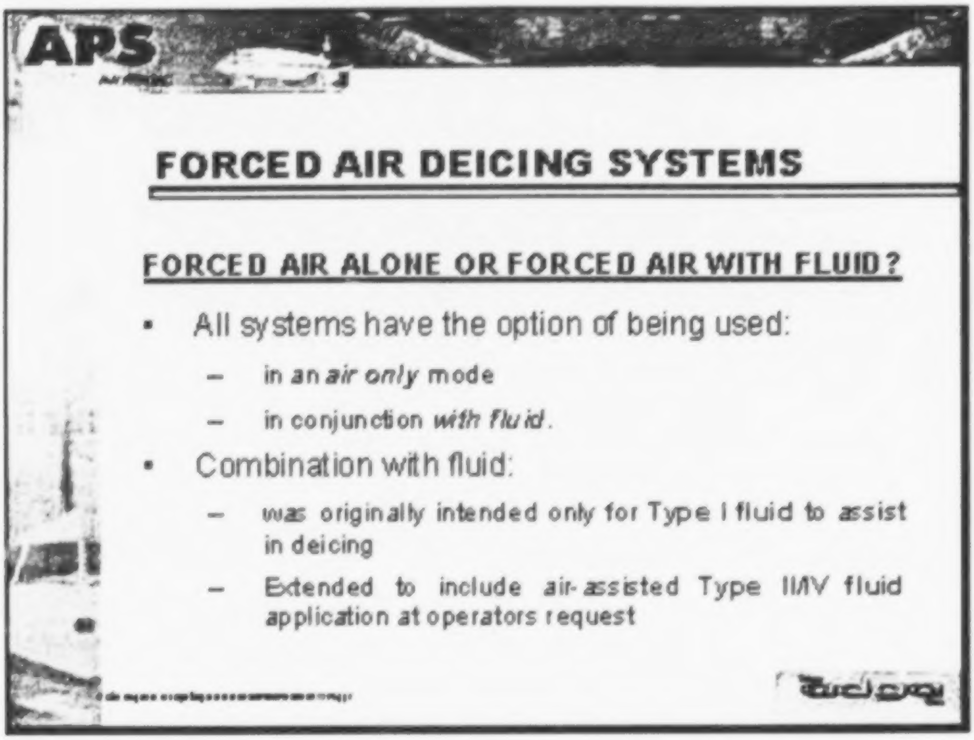
FMC-Air Pressure vs Distance at 90°

ambient 3°C and 1000mBAR
90 degrees



FMC-Air Temperature vs Distance

Ambient, 3°C and 1000mBAR



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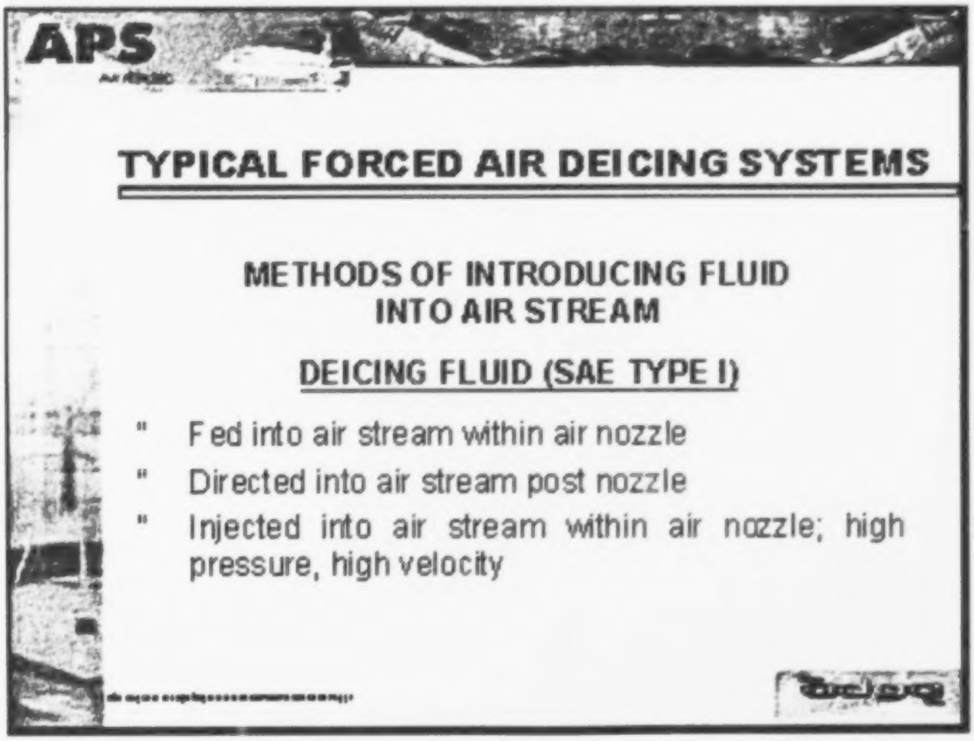
FORCED AIR DEICING SYSTEMS

FORCED AIR ALONE OR FORCED AIR WITH FLUID?

- All systems have the option of being used:
  - in an *air only* mode
  - in conjunction *with fluid*.
- Combination with fluid:
  - was originally intended only for Type I fluid to assist in deicing
  - Extended to include air-assisted Type II/IV fluid application at operators request



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TYPICAL FORCED AIR DEICING SYSTEMS

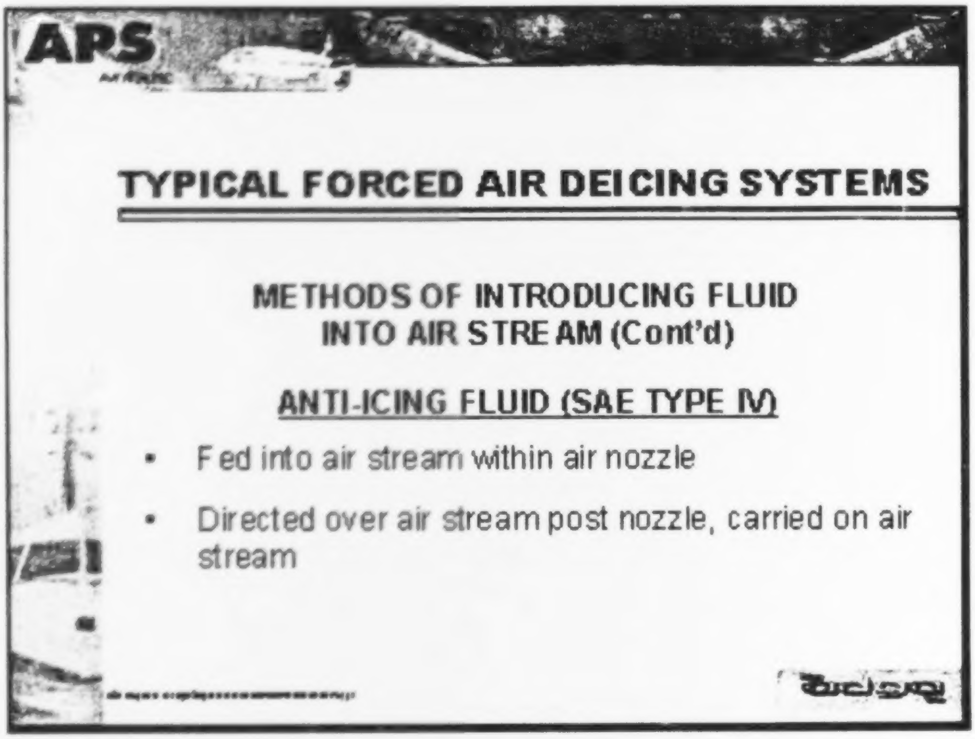
METHODS OF INTRODUCING FLUID
INTO AIR STREAM

DEICING FLUID (SAE TYPE I)

" Fed into air stream within air nozzle

" Directed into air stream post nozzle

" Injected into air stream within air nozzle; high pressure, high velocity



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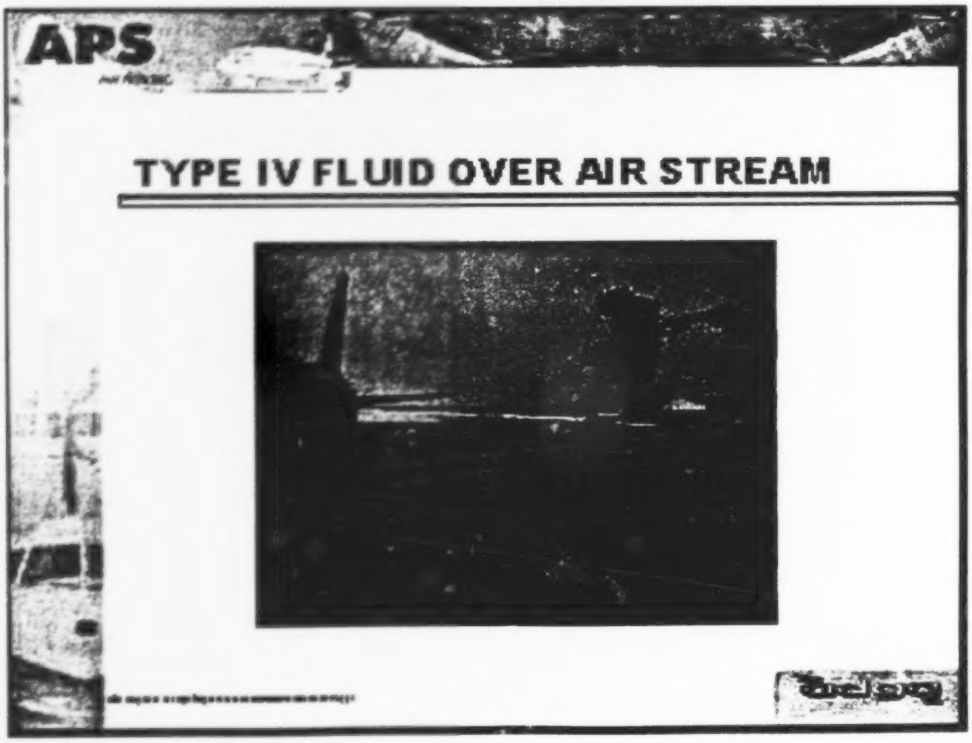
TYPICAL FORCED AIR DEICING SYSTEMS

METHODS OF INTRODUCING FLUID
INTO AIR STREAM (Cont'd)

ANTI-ICING FLUID (SAE TYPE IV)

- Fed into air stream within air nozzle
- Directed over air stream post nozzle, carried on air stream



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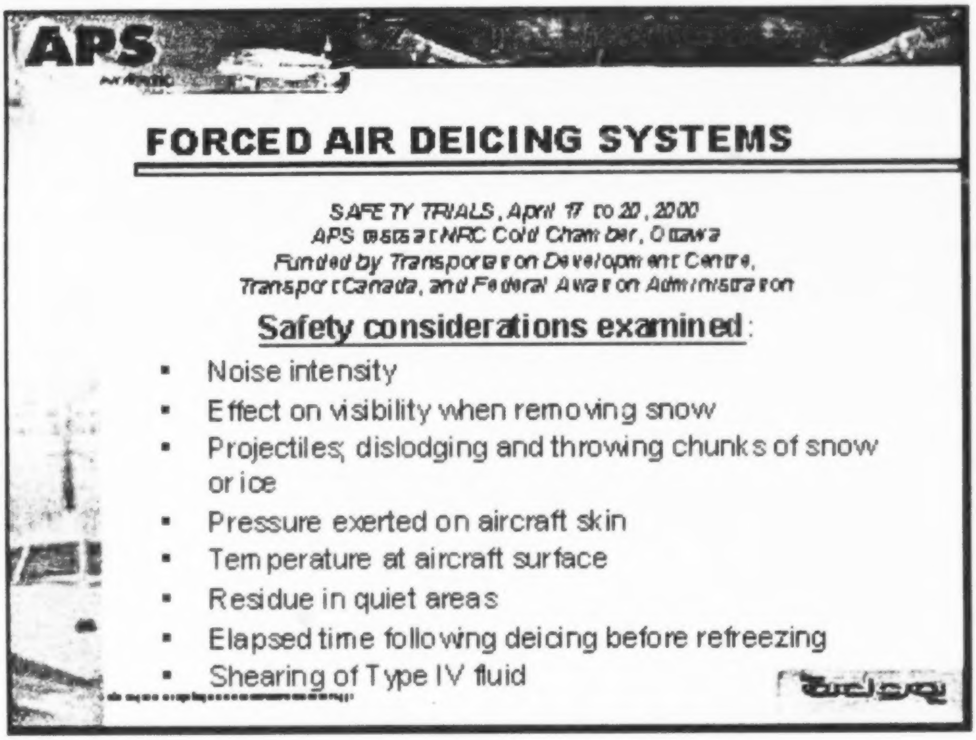
TYPE IV FLUID OVER AIR STREAM



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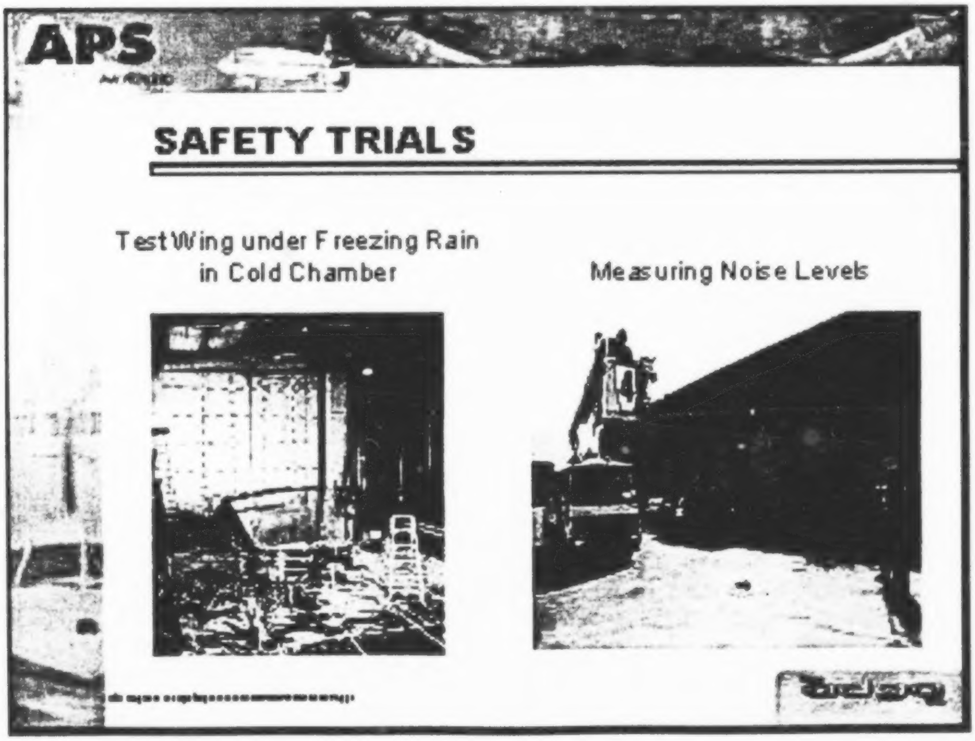
FORCED AIR DEICING SYSTEMS

SAFETY TRIALS, April 17 to 20, 2000
APS tests at NRC Cold Chamber, Ottawa
Funded by Transportation Development Centre,
Transport Canada, and Federal Aviation Administration

Safety considerations examined:

- Noise intensity
- Effect on visibility when removing snow
- Projectiles; dislodging and throwing chunks of snow or ice
- Pressure exerted on aircraft skin
- Temperature at aircraft surface
- Residue in quiet areas
- Elapsed time following deicing before refreezing
- Shearing of Type IV fluid

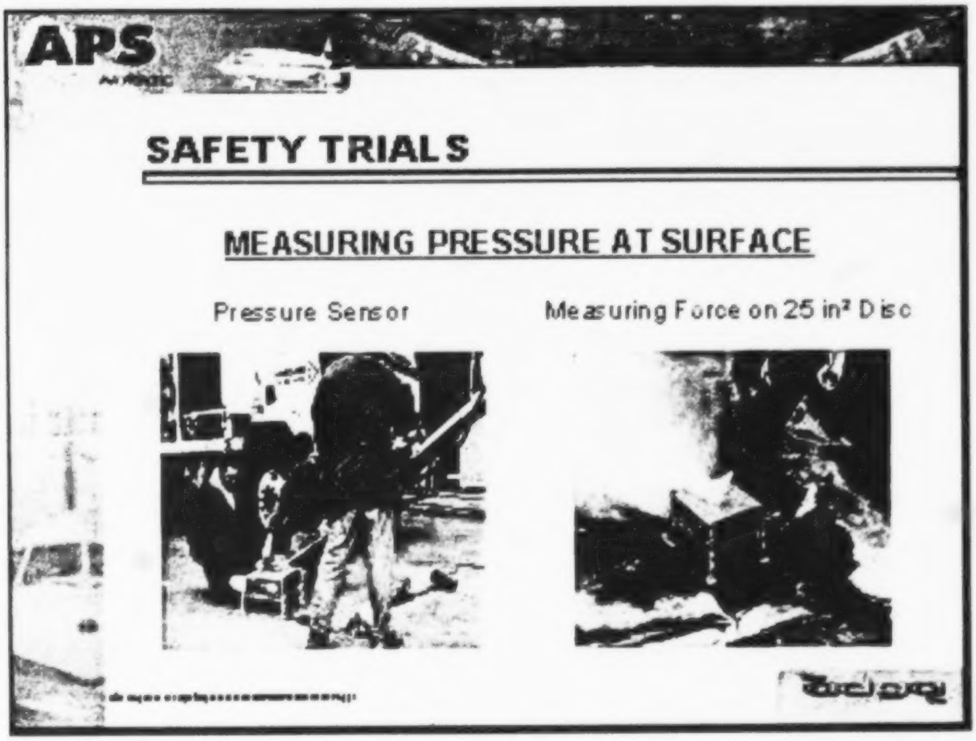


APS

SAFETY TRIALS

Test Wing under Freezing Rain in Cold Chamber

Measuring Noise Levels

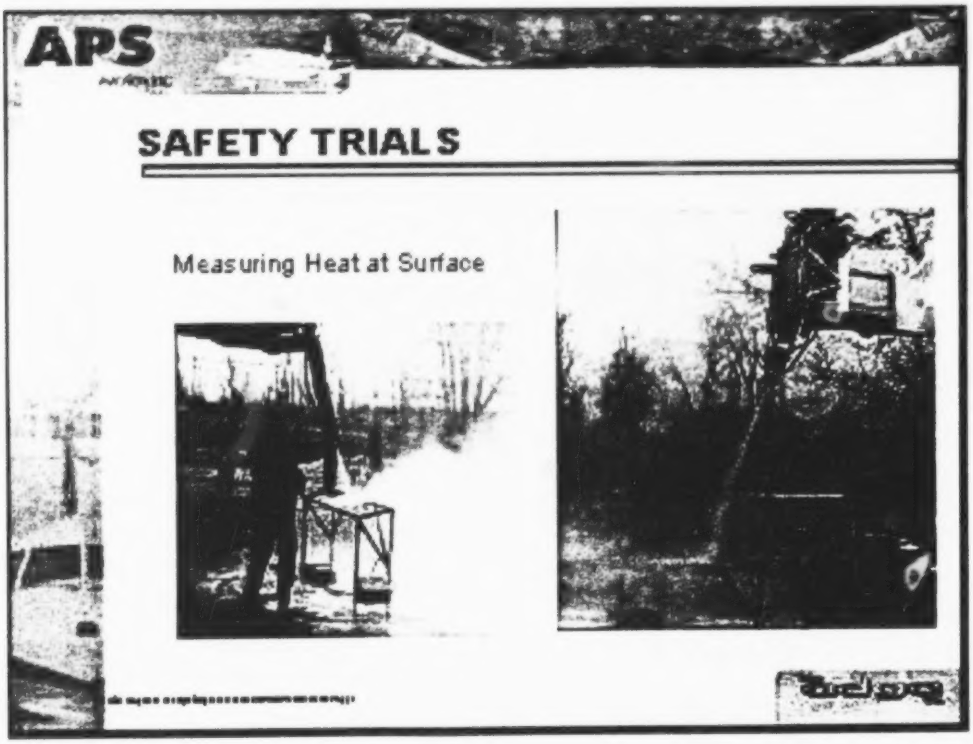


SAFETY TRIALS

MEASURING PRESSURE AT SURFACE

Pressure Sensor

Measuring Force on 25 in^2 Disc

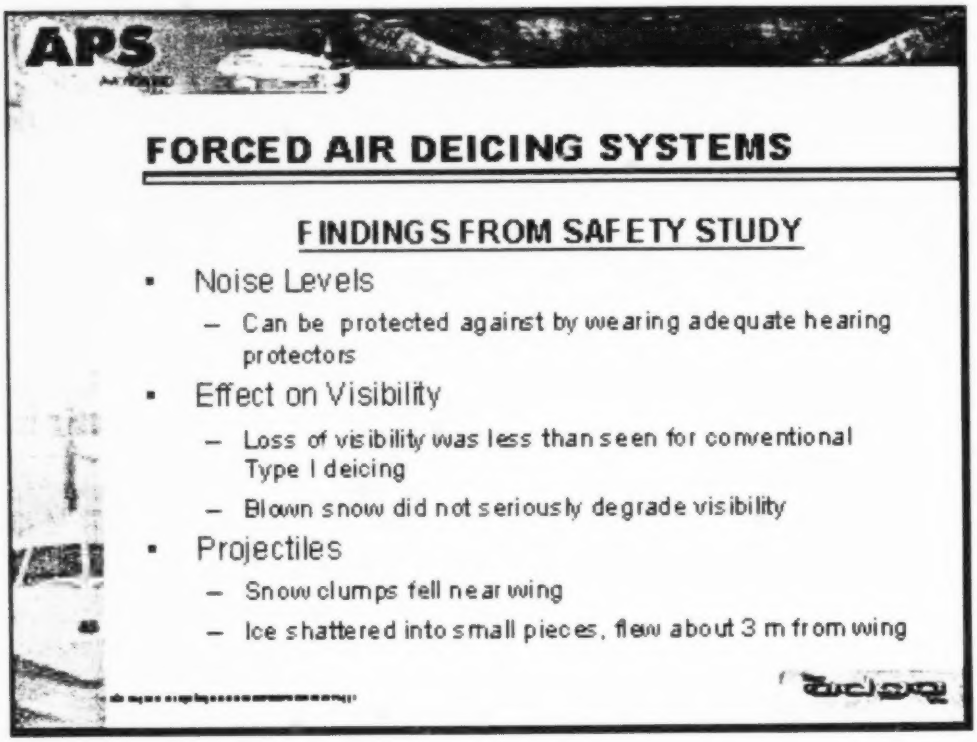


SAFETY TRIALS

Measuring Heat at Surface

Air with Type I Fluid on Dry Snow

Air alone on Dry Snow



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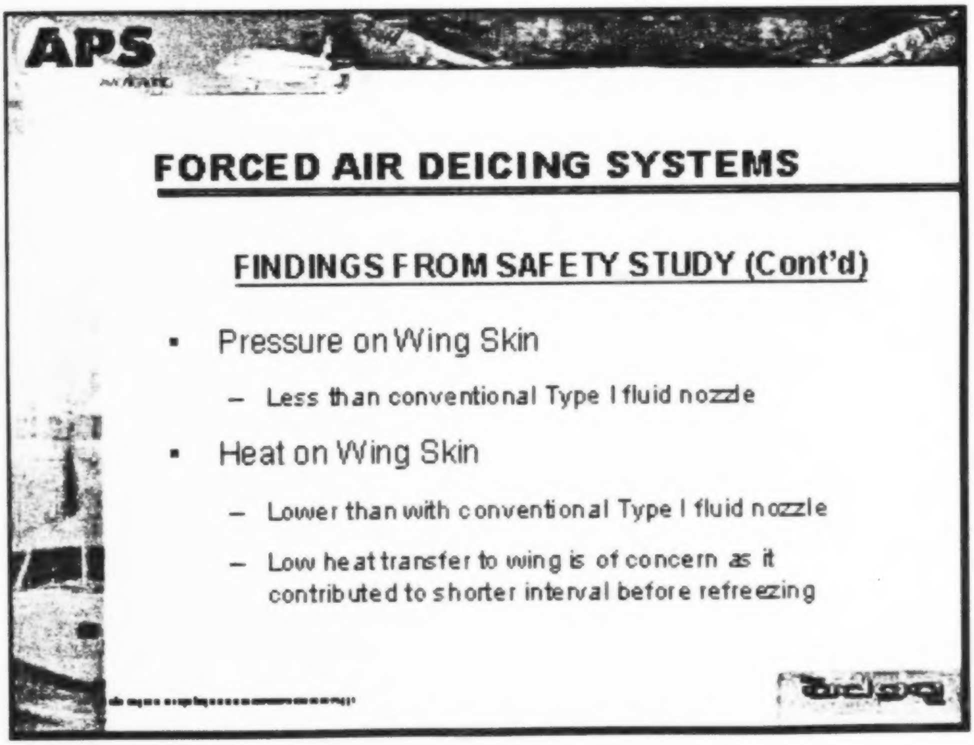
FORCED AIR DEICING SYSTEMS

FINDINGS FROM SAFETY STUDY

- Noise Levels
  - Can be protected against by wearing adequate hearing protectors
- Effect on Visibility
  - Loss of visibility was less than seen for conventional Type I deicing
  - Blown snow did not seriously degrade visibility
- Projectiles
  - Snow clumps fell near wing
  - Ice shattered into small pieces, flew about 3 m from wing



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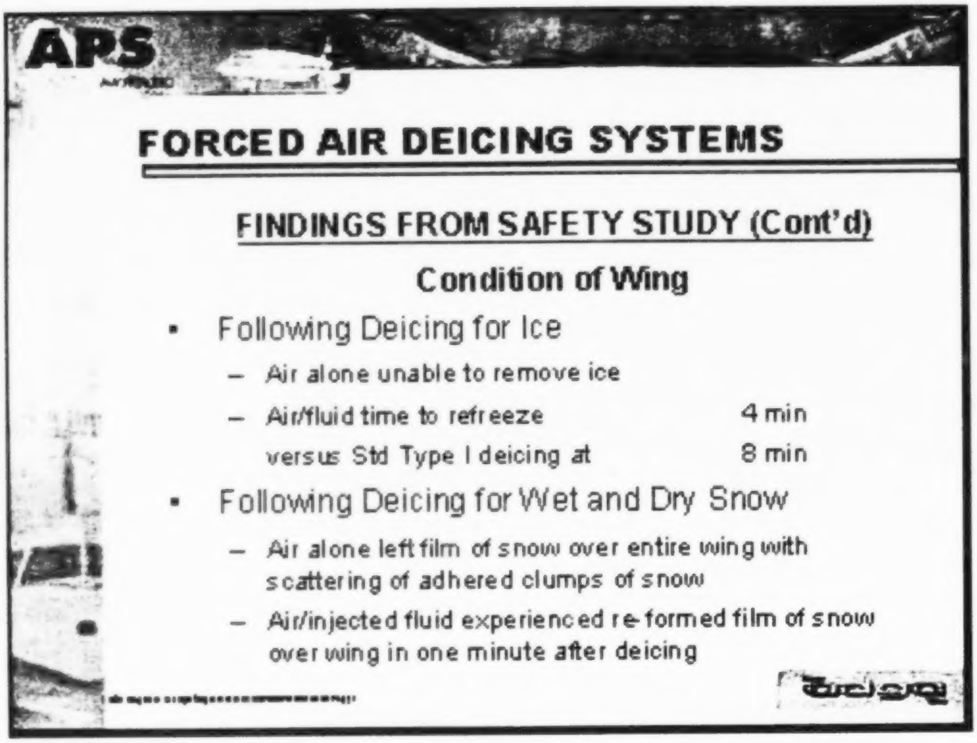
FORCED AIR DEICING SYSTEMS

FINDINGS FROM SAFETY STUDY (Cont'd)

- Pressure on Wing Skin
  - Less than conventional Type I fluid nozzle
- Heat on Wing Skin
  - Lower than with conventional Type I fluid nozzle
  - Low heat transfer to wing is of concern as it contributed to shorter interval before refreezing

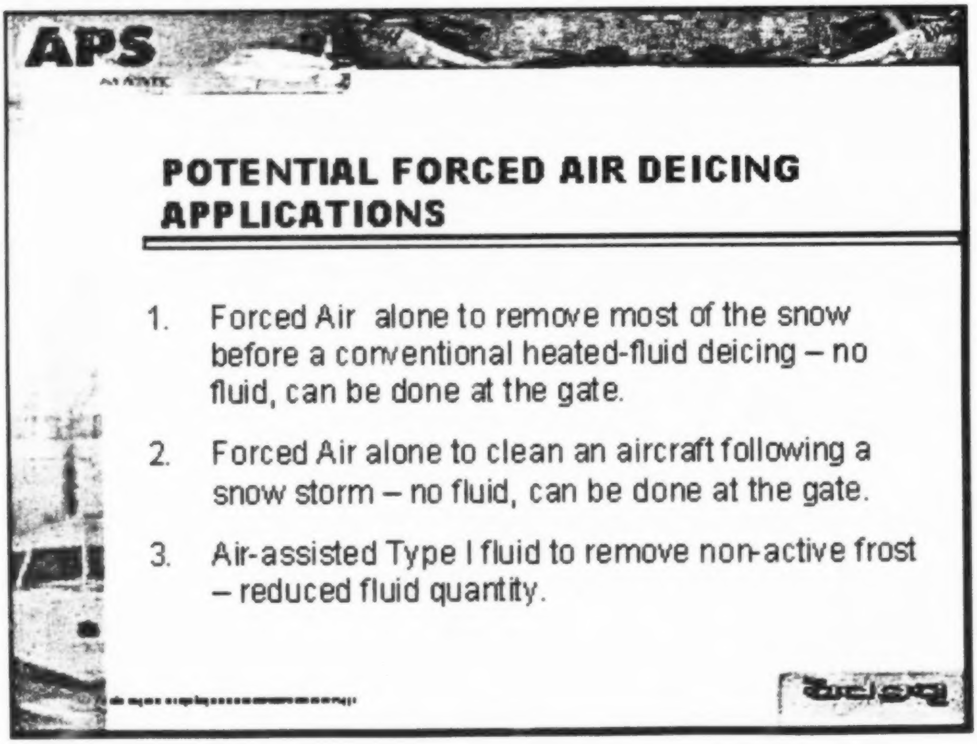


FORCED AIR DEICING SYSTEMS

FINDINGS FROM SAFETY STUDY (Cont'd)

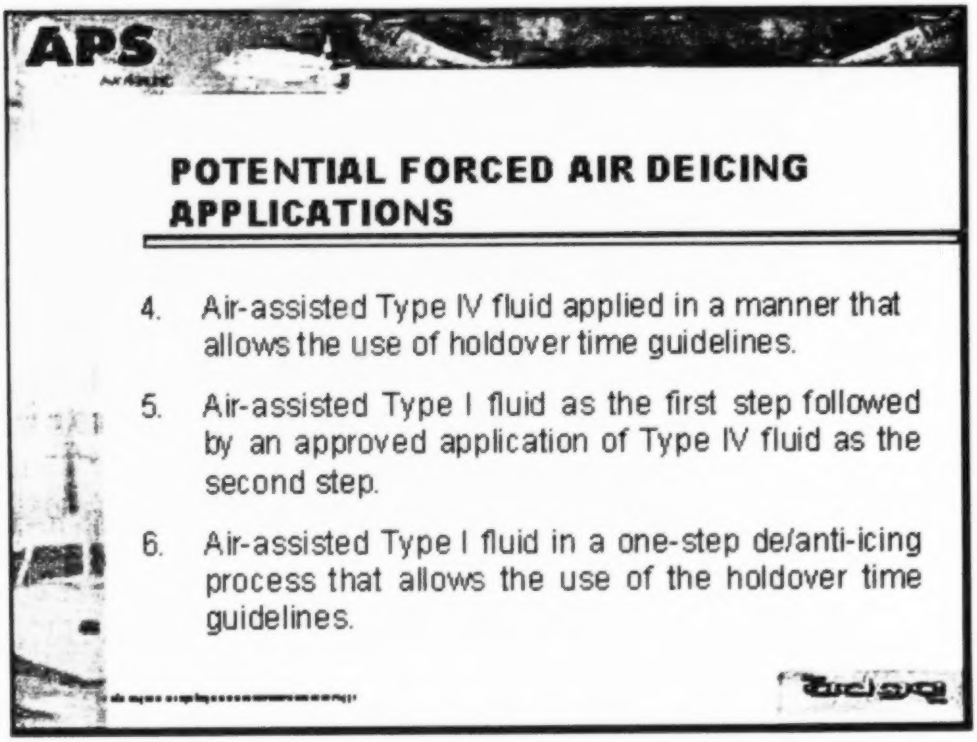
Condition of Wing

- Following Deicing for Ice
  - Air alone unable to remove ice
  - Air/fluid time to refreeze 4 min
    versus Std Type I deicing at 8 min
- Following Deicing for Wet and Dry Snow
  - Air alone left film of snow over entire wing with scattering of adhered clumps of snow
  - Air/injected fluid experienced re-formed film of snow over wing in one minute after deicing



POTENTIAL FORCED AIR DEICING APPLICATIONS

1. Forced Air alone to remove most of the snow before a conventional heated-fluid deicing – no fluid, can be done at the gate.
2. Forced Air alone to clean an aircraft following a snow storm – no fluid, can be done at the gate.
3. Air-assisted Type I fluid to remove non-active frost – reduced fluid quantity.



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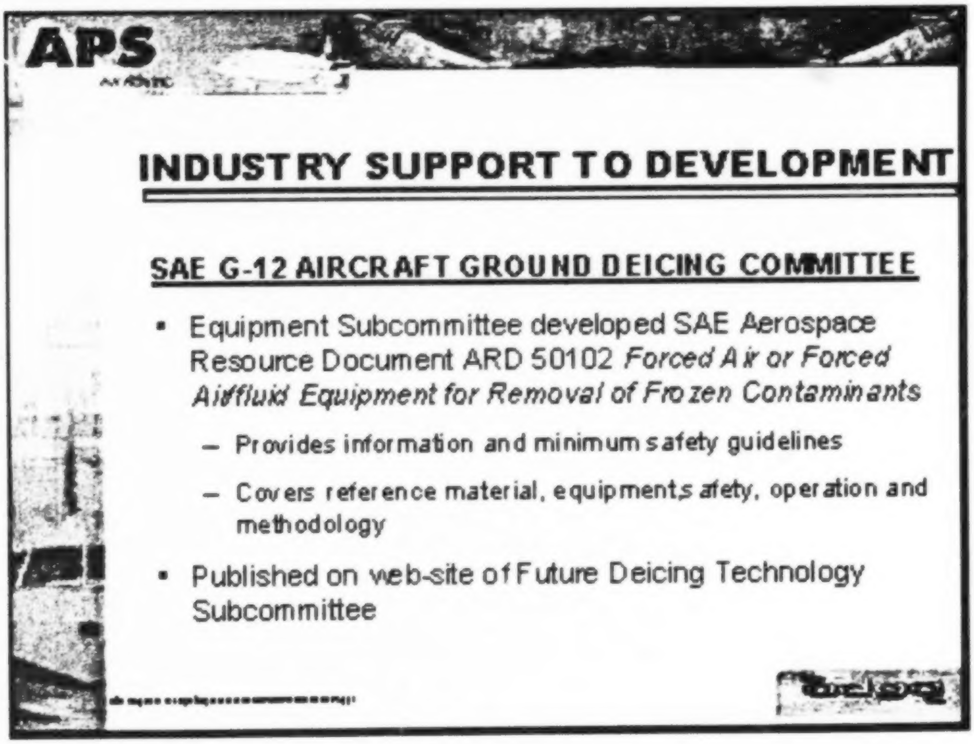
POTENTIAL FORCED AIR DEICING APPLICATIONS

4. Air-assisted Type IV fluid applied in a manner that allows the use of holdover time guidelines.
5. Air-assisted Type I fluid as the first step followed by an approved application of Type IV fluid as the second step.
6. Air-assisted Type I fluid in a one-step de/anti-icing process that allows the use of the holdover time guidelines.

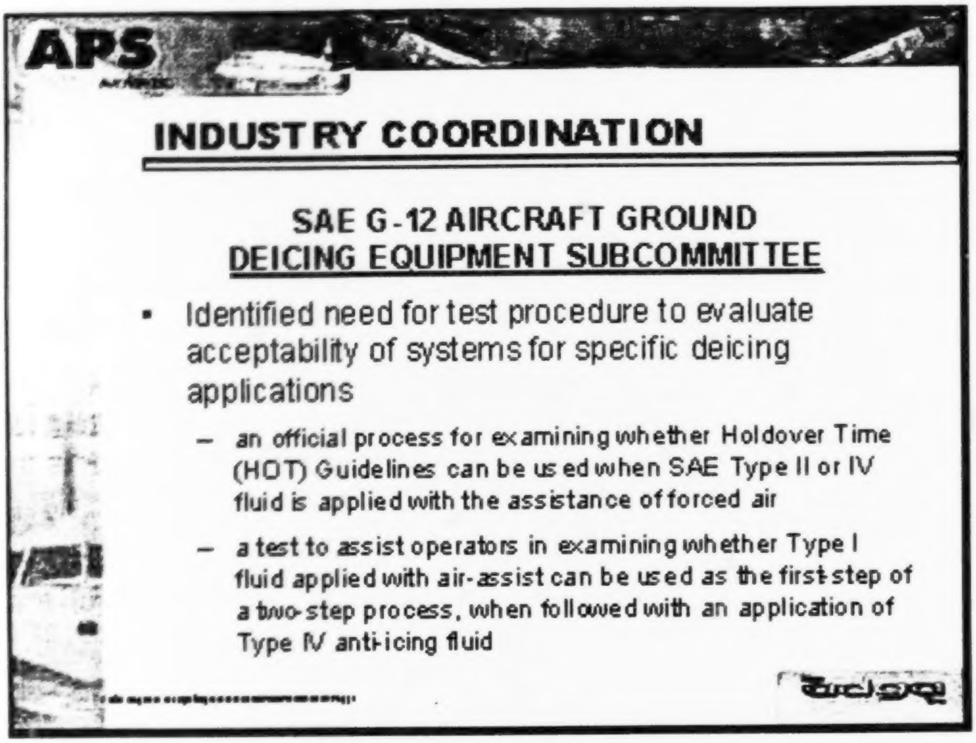


APS

INDUSTRY SUPPORT TO DEVELOPMENT

SAE G-12 AIRCRAFT GROUND DEICING COMMITTEE

- Equipment Subcommittee developed SAE Aerospace Resource Document ARD 50102 *Forced Air or Forced Air/fluid Equipment for Removal of Frozen Contaminants*
  - Provides information and minimum safety guidelines
  - Covers reference material, equipment safety, operation and methodology
- Published on web-site of Future Deicing Technology Subcommittee

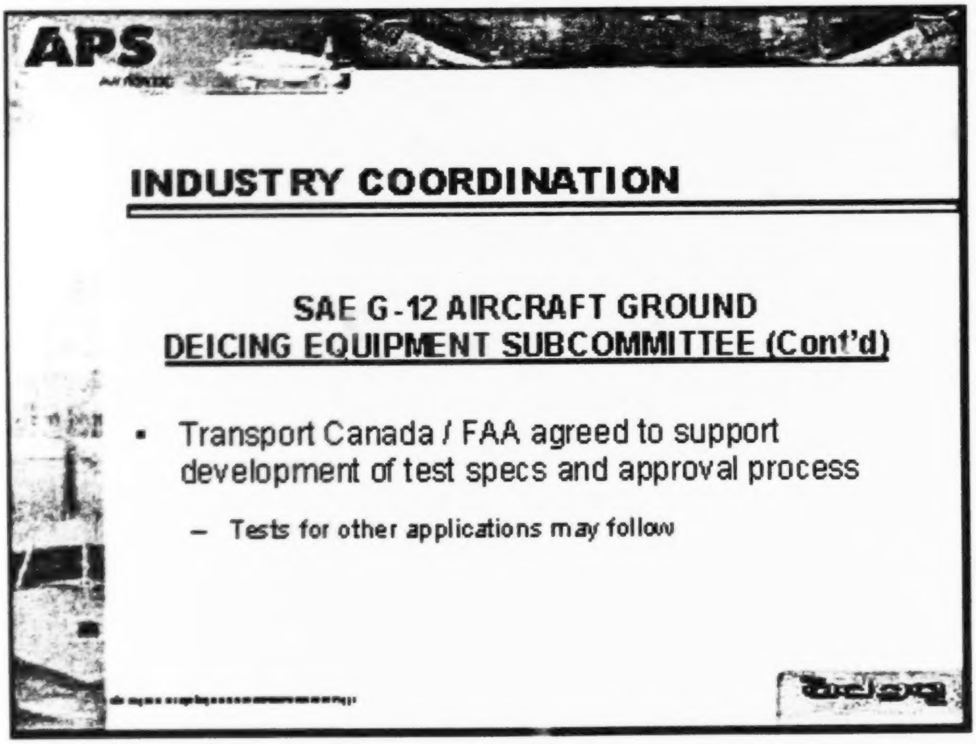


APS

INDUSTRY COORDINATION

SAE G-12 AIRCRAFT GROUND DEICING EQUIPMENT SUBCOMMITTEE

- Identified need for test procedure to evaluate acceptability of systems for specific deicing applications
  - an official process for examining whether Holdover Time (HOT) Guidelines can be used when SAE Type II or IV fluid is applied with the assistance of forced air
  - a test to assist operators in examining whether Type I fluid applied with air-assist can be used as the first step of a two-step process, when followed with an application of Type IV anti-icing fluid

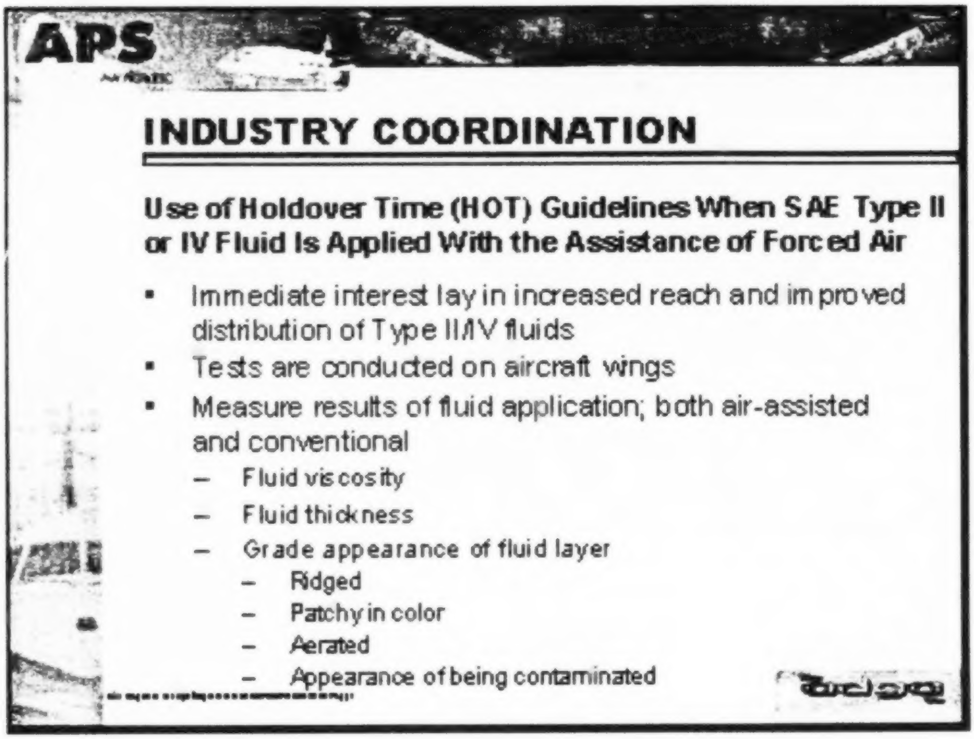


APS

INDUSTRY COORDINATION

SAE G-12 AIRCRAFT GROUND DEICING EQUIPMENT SUBCOMMITTEE (Cont'd)

- Transport Canada / FAA agreed to support development of test specs and approval process
  - Tests for other applications may follow

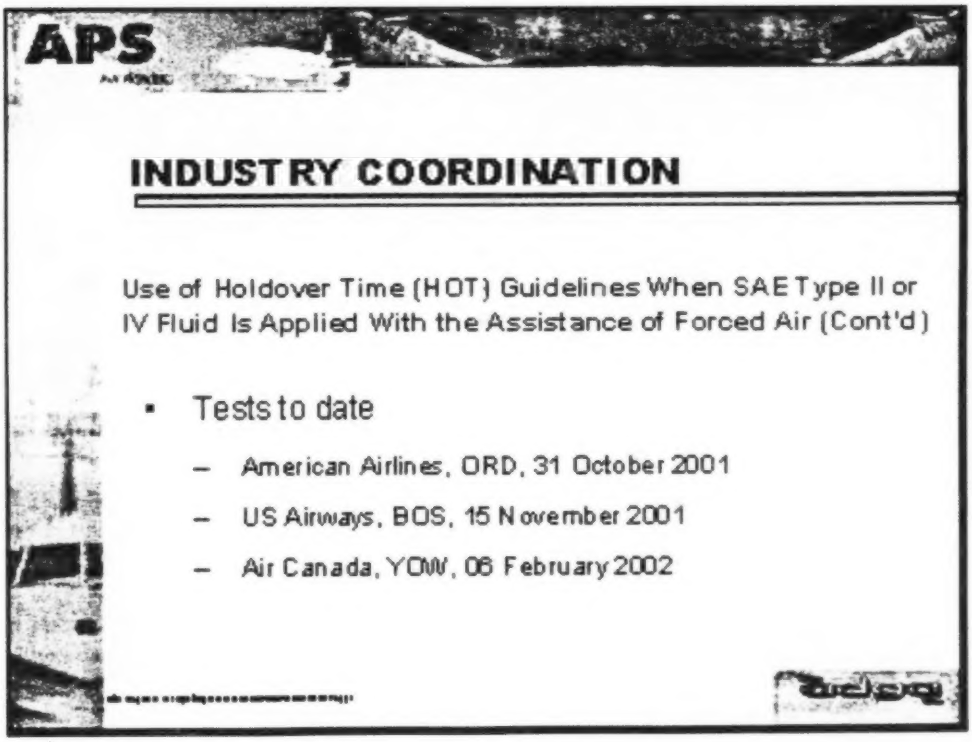


APS

INDUSTRY COORDINATION

Use of Holdover Time (HOT) Guidelines When SAE Type II or IV Fluid Is Applied With the Assistance of Forced Air

- Immediate interest lay in increased reach and improved distribution of Type II/IV fluids
- Tests are conducted on aircraft wings
- Measure results of fluid application; both air-assisted and conventional
  - Fluid viscosity
  - Fluid thickness
  - Grade appearance of fluid layer
    - Ridged
    - Patchy in color
    - Aerated
    - Appearance of being contaminated

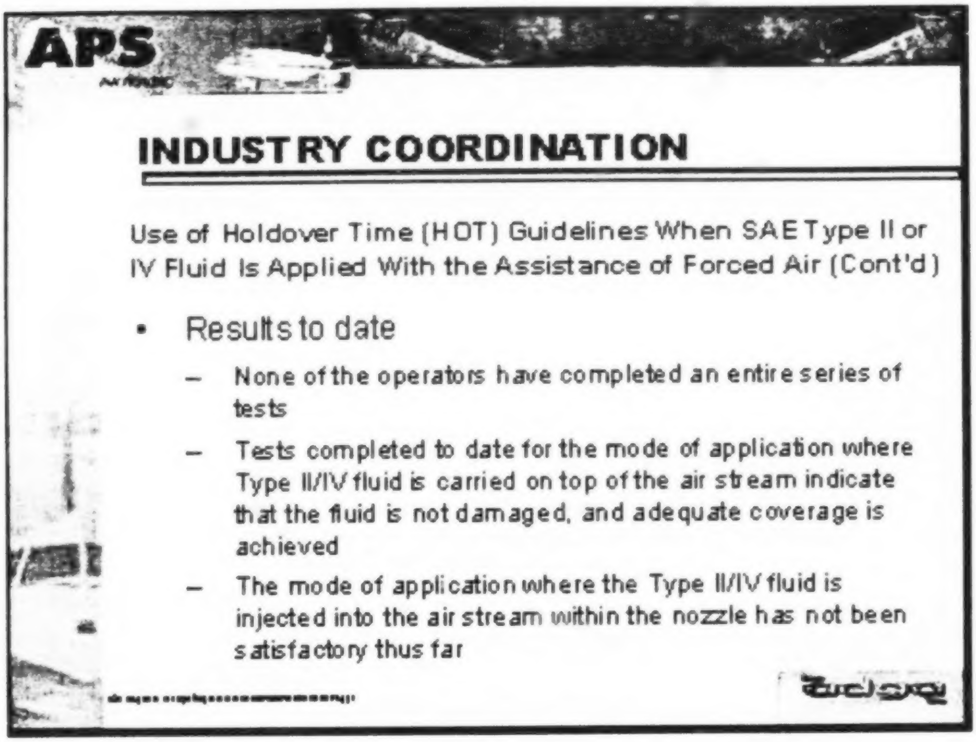


APS

INDUSTRY COORDINATION

Use of Holdover Time (HOT) Guidelines When SAE Type II or IV Fluid Is Applied With the Assistance of Forced Air (Cont'd)

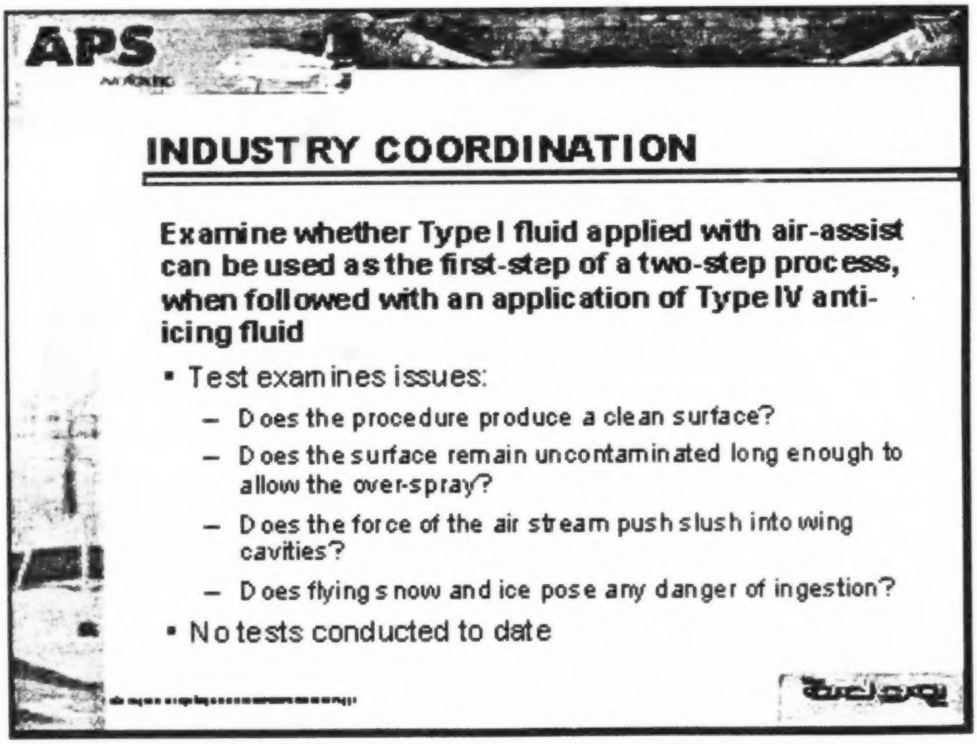
- Tests to date
  - American Airlines, ORD, 31 October 2001
  - US Airways, BOS, 15 November 2001
  - Air Canada, YOW, 06 February 2002



INDUSTRY COORDINATION

Use of Holdover Time (HOT) Guidelines When SAE Type II or IV Fluid Is Applied With the Assistance of Forced Air (Cont'd)

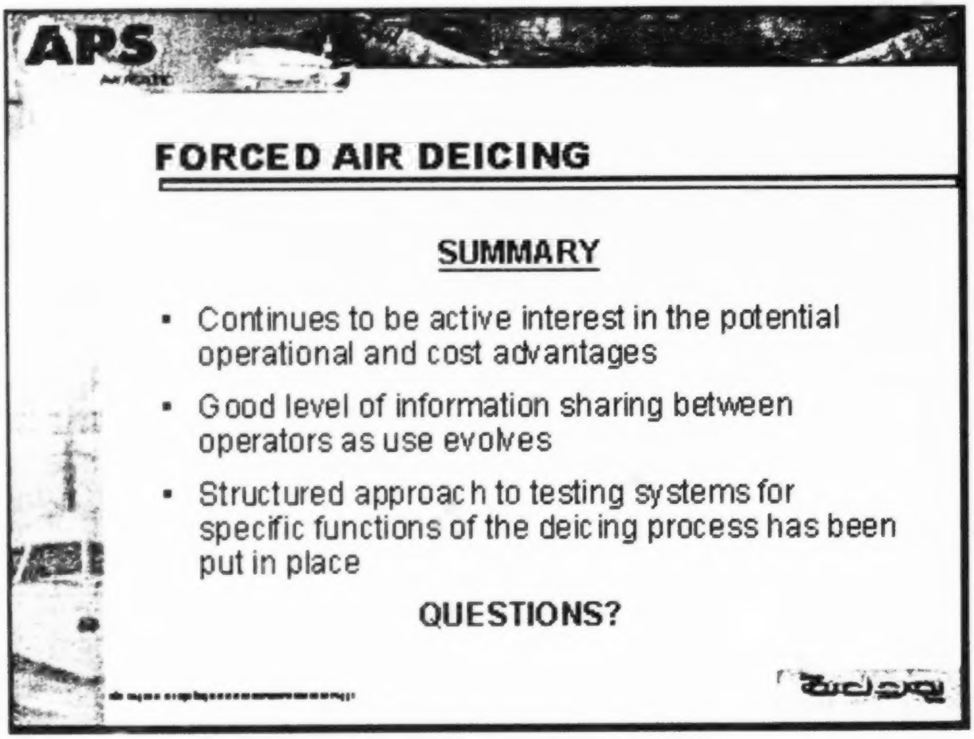
- Results to date
  - None of the operators have completed an entire series of tests
  - Tests completed to date for the mode of application where Type II/IV fluid is carried on top of the air stream indicate that the fluid is not damaged, and adequate coverage is achieved
  - The mode of application where the Type II/IV fluid is injected into the air stream within the nozzle has not been satisfactory thus far



INDUSTRY COORDINATION

Examine whether Type I fluid applied with air-assist can be used as the first-step of a two-step process, when followed with an application of Type IV anti-icing fluid

- Test examines issues:
  - Does the procedure produce a clean surface?
  - Does the surface remain uncontaminated long enough to allow the over-spray?
  - Does the force of the air stream push slush into wing cavities?
  - Does flying snow and ice pose any danger of ingestion?
- No tests conducted to date



FORCED AIR DEICING

SUMMARY

- Continues to be active interest in the potential operational and cost advantages
- Good level of information sharing between operators as use evolves
- Structured approach to testing systems for specific functions of the deicing process has been put in place

QUESTIONS?

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